Soils, Footings & Foundation

THE BASE

2021 International Residential Code

INSTRUCTOR:

Russell Thornburg
507.413.2027
russell.thornburg@gmail.com

Background:
Building Contractor - 1984 to present
Building Inspector Technician - 1997 - 2 years
Field Inspector – 1997 - 2020
Residential Plans Examiner – 1997 – to present
Code Development Committee – started 2001
Instructor – 1998 - present
Code Consultant – 2005 to present
Program Manager – Short Stint

www.ThornburgCodeServices.com

"Disclaimer"

- The opinions expressed in this presentation are the opinions of the presenter Russell Thornburg and do not represent the official opinion *of* the *International Code Council (ICC) or that* of the administrative authority of *any* jurisdiction. As always, the Building Official of the Jurisdiction, County or State has the final authority.
- This presentation is used as a guideline for the instructor and no part of this work may be reproduced, distributed or transmitted in any form or by any means, including, without limitation, electronic, optical or mechanical, without advance written permission from Russell Thornburg and from those who gave Russell permission.

3

"Disclaimer"

- The text in this presentation does not necessarily represent actual code language. The presented text may summarize, highlight or generalize the code section. Additional provisions or exceptions may be included in the actual code section. References to the code sections are given for the purpose of verifying the complete provisions of the code section.
- Participants of the code are responsible for reading, studying, (reading & studying) interpreting (attending code panels & committee discussions), and enforcing the code as directed by the their code administrators.

In Reference to all: Materials / Products / Illustrations / Pictures and comments of this Presentation

"Do not Assume:"

- …that any picture in this presentation is in compliance of code, manufacturer's listing etc…
- …that any product has been fully researched to the intent of the code
- …that any product that can be sold / purchased meets any code requirements
- …that any one product has been tested and meets the intent of any past/current adopted codes
- …that any product has been properly installed unless you have done a complete thorough research of that product through the manufacturer's installation instruction, approved acceptable tested listing, and have reviewed its current evaluation report requirements by approved testing agency.

5

QUESTIONS ???

Have a question?

6

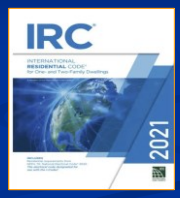
Resources Materials

The text and the material that is in this program come from the International Residential Code, the International Building Code, and from publications published by the Masonry Institute of America, American Society for Testing and Materials, American Concrete Institute, the Concrete Reinforcing Steel Institute.

7

IRC Provisions

- **Prescriptive Code.**
- **"Cookbook" with ingredients.**
- **Limits.**
- **It is the worst house you can build by law!**



Engineered Design

- **When structural element exceeds limits of IRC.**
- **"Accepted engineering practice."**
- **May be portion or entire structure.**
- **Reference IBC.**

R301.1.3

Resources Tools

10

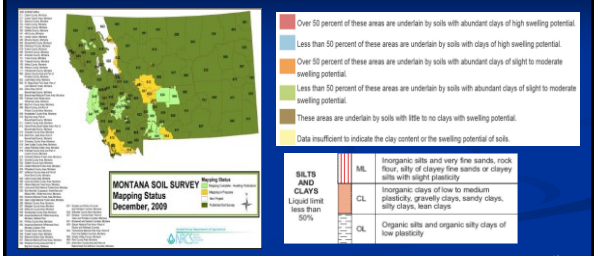
Purpose

- Inspection of the foundation shall be made after poles or piers are set or trenches or basement areas are excavated and any required forms erected and any required reinforcing steel is in place and supported prior to the placing of concrete. The foundation inspection shall include excavations for thickened slabs intended for the support of bearing walls, partitions, structural supports, or equipment and special requirements for wood foundations.
- The purpose of the inspection task is to verify that soils, footings & foundtions comply with all the code requirements and all JHA ordinances & restrictions.
- Before any inspection is made the approved construction document must be reviewed before an adequate inspection can be made.

R109.1.1 Foundation inspection.

11

Soils – Montana



12

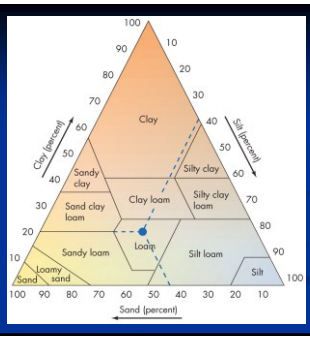
Soil

- Definitions:
  - Supporting rooted plant life (Pedology)
  - Solid Earth materials altered by physical, chemical, and biological processes (Geology)
- Land-use planning: Soil suitability is large part of land capability
  - Bearing capacity
  - Water table
- Waste disposal: Soil properties are critical

13

Soil Texture

- Verbal description of particle-size distribution
- Example:
  - 20% clay
  - 37% silt
  - 43% sand



14

Soil Water

- Soil pores filled with air or liquid (most often water)
- Soil in saturated condition, if filled with water; otherwise unsaturated
- The saturation level of soil water changes with climate (hardly saturated in arid climate) and seasons (deficit vs. surplus conditions)
- Movement of water: important in pollution monitoring and management

15

Soil Taxonomy

- Soil classification based on physical and chemical properties of the soil profile
- Unified soil classification system: widely used in engineering practice, based on particle size, abundance of organic material, and odor
- USDA taxonomy: widely used in agriculture
- Descriptive:
  - Pedocal – lime-rich (arid)
  - Pedalfer – iron-rich (humid)

16

TABLE R405.1 Unified Soil Classification System Used by Engineers

		Major Division		Group Symbol	Soil Group Name
COARSE-GRAINED SOILS (More than half of material larger than 0.074 mm)	GRAVELS	Clean gravels	Less than 5% fines	GW	Well-graded gravel
				GP	Poorly graded gravel
		Dirty gravels	More than 12% fines	GM	Silty gravel
				GC	Clayey gravel
	SANDS	Clean sands	Less than 5% fines	SW	Well-graded sand
				SP	Poorly graded sand
		Dirty sands	More than 12% fines	SM	Silty sand
				SC	Clayey sand
FINE-GRAINED SOILS (More than half of material smaller than 0.074 mm)	SILTS, NONPLASTIC			ML	Silt
				MH	Micaceous silt
				OL	Organic silt
	CLAYS, PLASTIC			CL	Silty clay
				CH	High plastic clay
				OH	Organic clay
Predominantly organics				PT	Peat and muck

Note: The value of 0.074 mm is the boundary between sand and silt that engineers use. Geologists use 0.063 mm for the same boundary.

17

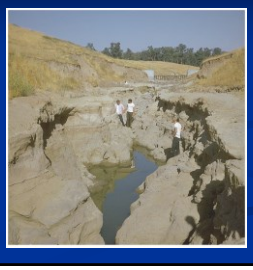
Engineering Properties of Soils (1)

- Strength: Soil's ability to resist deformation, function of cohesive and frictional forces between soil particles
- Sensitivity: Measuring the changes in soil strength from disturbances
- Compressibility: Soil's tendency to consolidate or decrease in volume

18

Engineering Properties of Soils (2)

- Erodibility: The ease with which soil is removed by wind or water
- Hydraulic conductivity: The ease of soil to allow water to move through
- Corrosion potential: Chemical interaction with metals



19

Engineering Properties of Soils (3)

- Ease of excavation: The degree of ease to remove soil using certain equipment during construction
- Shrink-swell potential: Soil's tendency to gain or lose water
  - Expansive soils: Causing significant environmental problems in the U.S.
  - Changes in moisture content
  - Topography and drainage also significant

20

Settlement Compared to Shrinkage

Shrink is a recoverable decrease in volume meaning if the soil gets wet, the soil will increase volume again.

SETTLEMENT ≠ SHRINK

Settlement is a permanent non-recoverable volume change due to water or air being "squeezed" out of the soil.

21

Expansive Soils

SWELLING

22

Parameters Used in Classification System

- Particle Size
- Water Holding and Plasticity
- Organic Content

23

ASTM Standards

- Lab Data Classification is by ASTM D2487
- Classification of Peat Samples, see ASTM D 4427
- Field Classification is by D2488

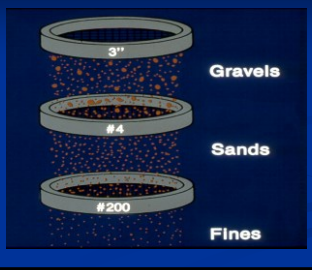
24

Definitions

- Particle Sizes
  - Gradation or Mechanical Analyses
  - Sieves for larger particles
  - Hydrometer for fine particles

25

Sieve Analyses



26

Sieve Analysis

27

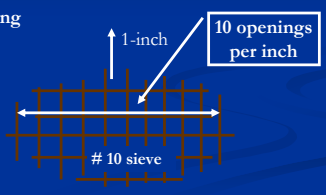
Sieve Designation - Large

Sieves larger than the #4 sieve are designated by the size of the openings in the sieve

28

Sieve Designation - Smaller

Smaller sieves are numbered according to the number of openings per inch



29

Particle Size Definition

- System based only on particles smaller than 3-inches
- Cobbles are 3"to 12"
- Boulders are > 12"

30

Gravel / Sand / Fines

- Gravels are between # 4 sieve and 3”
- Sands are between # 200 sieve and # 4 sieve
- Fines are smaller than # 200 sieve

31

Two Parts to the Foundation System

- Substructure
  - Consists of structural components serving as medium through which building loads are transmitted to supporting earth (soil or rock).
- Soil
  - Using soil (including rock) as structural material to carry the load of the building.

32

Making Basic Foundation Decisions

- Site Conditions
  - The topography
  - Water table location
  - Soil type

33

34

35

Fill

36

Soil Classifications

US Army Corps of Engineers (USCE) divides soils that have been classified into the major soil categories by letter symbols, such as—

- S for sand.
- G for gravel.
- M for silt.
- C for clay.

37

Plasticity Index (PI) (%)

FINE-GRAINED SOILS
(50% or more of material is smaller than No. 200 sieve size.)

SILTS AND CLAYS Liquid limit less than 50%	ML	Inorganic silts and very fine sands, rock flour, silty of clayey fine sands or clayey silts with slight plasticity
	CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays
	OL	Organic silts and organic silty clays of low plasticity
SILTS AND CLAYS Liquid limit 50% or greater	MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts
	CH	Inorganic clays of high plasticity, fat clays
	OH	Organic clays of medium to high plasticity, organic silts
HIGHLY ORGANIC SOILS	PT	Peat and other highly organic soils

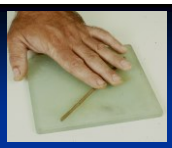
38

Soil Identification

- A soil that can be rolled into a 1/8-inch diameter thread at some moisture content has some plasticity. Materials that cannot be rolled in this manner are nonplastic or have very low plasticity. The number of times that the thread may be lumped together and the rolling process repeated without crumbling and breaking is a measure of the degree of plasticity of the soil. After the PL is reached, the degree of plasticity may be described as follows:
- Roll or a Thread Test
  - Highly plastic soils, (CH). The soil may be remolded into a ball and the ball deformed under extreme pressure by the fingers without cracking or crumbling.

39

Soil Identification



Roll or a Thread Test

- Medium plastic soils, (CL). The soil may be remolded into a ball, but the ball will crack and easily crumble under pressure of the fingers. Low plastic soils, (CL), (ML), or (MH). The soil cannot be lumped together into a ball without completely breaking up.
- Organic materials, (OL) or (OH). Soils containing organic materials or mica particles will form soft spongy threads or balls when remolded. Nonplastic soils, (ML) or (MH). Nonplastic soils cannot be rolled into a thread at any moisture content.

40

Soils Test

- Areas proven to have poor soils
- Building official shall determine if soils test required
- Test by approved agency
- Test by approved method

R401.4

41

42

Soil Characteristics Table R405.1

SOIL GROUP	UNIFIED SOIL CLASSIFICATION SYSTEM SYMBOL	SOIL DESCRIPTION	DRAINAGE CHARACTERISTICS[a]	FROST HEAVE POTENTIAL	VOLUME CHANGE POTENTIAL EXPANSION[b]
	GM	Silty gravels, gravel-sand-silt mixtures	Good	Medium	Low
	SM	Silty sand, sand-silt mixtures	Good	Medium	Low
Group II	GC	Clayey gravels, gravel-sand-clay mixtures	Medium	Medium	Low
	SC	Clayey sands, sand-clay mixture	Medium	Medium	Low
	ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity	Medium	High	Low
	CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays	Medium	Medium	Medium to Low
Group III	CH	Inorganic clays of high plasticity, fat clays	Poor	Medium	High
	MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts	Poor	High	High
Group IV	OL	Organic silts and organic silty clays of low plasticity	Poor	Medium	Medium
	OH	Organic clays of medium to high plasticity, organic silts	Unsatisfactory	Medium	High
	Pt	Peat and other highly organic soils	Unsatisfactory	Medium	High

43

Engineering Properties of Soils

- Shrink-swell potential: Soil's tendency to gain or lose water
  - Expansive soils: Causing significant environmental problems in the U.S.
  - Changes in moisture content
  - Topography and drainage also significant

44

Foundations on Expansive Soils.

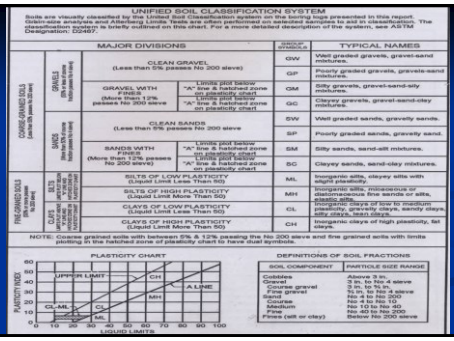
Foundation and floor slabs for buildings located on expansive soils shall be designed in accordance with Section 1808.6 of the International Building Code.

Exception: Slab-on-ground and other foundation systems which have performed adequately in soil conditions similar to those encountered at the building site are permitted subject to the approval of the building official.

R403.1.8.1 Expansive soils classifications.
Soils meeting all four of the following provisions shall be considered expansive, except that tests to show compliance with Items 1, 2 and 3 shall not be required if the test prescribed in Item 4 is conducted:

1. Plasticity Index (PI) of 15 or greater, determined in accordance with ASTM D 4318.
2. More than 10 percent of the soil particles pass a No. 200 sieve, determined in accordance with ASTM D 422.
3. More than 10 percent of the soil particles are less than 5 micrometers in size, determined in accordance with ASTM D 422.
4. Expansion Index greater than 20, determined in accordance with ASTM D 4829.

45



UNIFIED SOIL CLASSIFICATION SYSTEM

Soils are visually classified in accordance with ASTM D 2488 as presented in this report. Grain-size analysis and Atterberg Limits Tests are often performed on selected samples to aid in classification. The classification system is briefly outlined on this chart. For a more detailed description of the system, see ASTM Designation: D2487.

MAJOR DIVISIONS			GROUP SYMBOLS	TYPICAL NAMES
COARSE-GRAINED SOILS (more than half of material is larger than No. 200 sieve)	GRAVELS (more than half of coarse fraction is larger than No. 4 sieve)	CLEAN GRAVEL (Less than 5% passes No 200 sieve)	GW	Well graded gravels, gravel-sand mixtures.
			GP	Poorly graded gravels, gravels-sand mixtures.
		GRAVEL WITH FINES (More than 12% passes No 200 sieve) Limits plot below "A" line & hatched zone on plasticity chart	GM	Silty gravels, gravel-sand-silty mixtures.
		Limits plot above "A" line & hatched zone on plasticity chart	GC	Clayey gravels, gravel-sand-clay mixtures.
	SANDS (more than half of coarse fraction is smaller than No. 4 sieve)	CLEAN SANDS (Less than 5% passes No 200 sieve	SW	Well graded sands, gravelly sands.
			SP	Poorly graded sands, gravelly sand.
		SANDS WITH FINES (More than 12% passes No 200 sieve) Limits plot below "A" line & hatched zone on plasticity chart	SM	Silty sands, sand-silt mixtures.
		Limits plot above "A" line & hatched zone on plasticity chart	SC	Clayey sands, sand-clay mixtures.
FINE-GRAINED SOILS (more than half of material is smaller than No. 200 sieve)	SILTS AND CLAYS (liquid limit less than 50)	SILTS OF LOW PLASTICITY (Liquid Limit Less Than 50)	ML	Inorganic silts, clayey silts with slight plasticity.
		SILTS OF HIGH PLASTICITY (Liquid Limit More Than 50)	MH	Inorganic silts, micaceous or diatomaceous fine sands or silts, elastic silts.
		CLAYS OF LOW PLASTICITY (Liquid Limit Less Than 50)	CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays.
		CLAYS OF HIGH PLASTICITY (Liquid Limit More Than 50)	CH	Inorganic clays of high plasticity, fat clays.

NOTE: Coarse grained soils with between 5% & 12% passing the No 200 sieve and fine grained soils with limits plotting in the hatched zone of plasticity chart to have dual symbols.

PLASTICITY CHART

DEFINITIONS OF SOIL FRACTIONS

SOIL COMPONENT	PARTICLE SIZE RANGE
Cobbles	Above 3 in.
Gravel	3 in. to No 4 sieve
Course gravel	3 in. to ¾ in.
Fine gravel	¾ in. to No 4 sieve
Sand	No 4 to No 200
Course	No 4 to No 10
Medium	No 10 to No 40
Fine	No 40 to No 200
Fines (silt or clay)	Below No 200 sieve

46

The Building Official

- R104.1 General.
  - The building official is hereby authorized and directed to enforce the provisions of this code. The building official shall have the authority to render interpretations of this code and to adopt policies and procedures in order to clarify the application of its provisions.

47

The Big Picture

- Cohesionless soils (sand or gravel)
- Cohesive soils (silt and clay matrix soils)

48

Water and its affect

- Water weighs 62.4 pcf and will exert that pressure per foot of head depth.
- As we get deeper below the surface the pressure will increase.

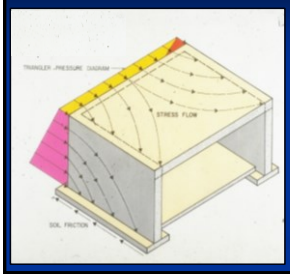
49

EQUIVALENT FLUID PRESSURE:

Water -	62.4 pcf	Gravel -	135 pcf
Concrete -	140 pcf	Silt -	110 pcf
		Clay -	100 pcf

50

Pressure exert to Foundation Wall



The lateral soil pressure, P, at depth, h, shall be determined using a triangular uniform load (increasing with depth) in accordance with Figure 5.3 and the following formula:

$P = qh$ (psf)

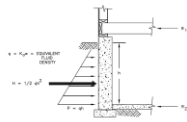
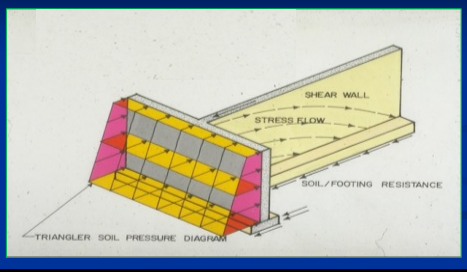


FIGURE 5.3
TRIANGULAR PRESSURE DISTRIBUTION ON A BASEMENT FOUNDATION WALL

51

Pressure exert to Foundation Wall

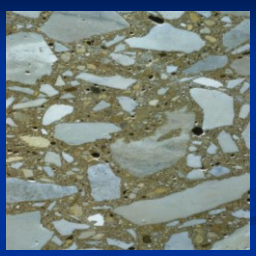


52

53

Mixture

Concrete should be made up of :
- 10% cement
- 20% water
- 30% sand
- 40% gravel



54

Water / Cement Ratio

Strength Losses

Add 20 gallons to a 10 yard load and we can lose 400 to 500 psi

55

Water / Cement Ratio

Shrinkage

- 25% to 30% is for hydration reaction
- 40% to 50% to make concrete workable
- The extra water added will evaporate out and concrete shrinks and cracks

56

Water / Cement Ratio

Reduced density, increased porosity

- Add to much water and you increase volume and after drying all you have is air.

57

General Knowledge

Evaporation

- 32 gallons of water per yard of concrete
- Including footings, walls and slab about 400 to 700 gallons of water vapor will enter the house within a 3 year period

58

Water / Cement Ratio

Permeability

- After concrete cures, those capillary voids let water and vapor move through finished slabs and walls.

59

Code Language + Standards

- Concrete shall have a min. specified compressive strength of , as shown in Table R402.2.
- Concrete subject to moderate or severe weathering as indicated in Table R301.2(1) shall be air entrained as specified in Table R402.2.
- The maximum weight of fly ash, other pozzolans, silica fume, slag or blended cements that is included in concrete mixtures for garage floor slabs *and* for exterior porches, carport slabs *and* steps that will be exposed to deicing chemicals *shall not* exceed the percentages of the total weight of cementitious materials specified in Section 4.2.3 of ACI 318.
- *Materials used in concrete, the concrete itself and forms shall conform to requirements of this section or ACI 318. R404.1.3.3 -Concrete, Materials for concrete…*

R402.2

60

Code Language + Standards

R404.1.3.3.2 Concrete mixing and delivery. Mixing and delivery of concrete shall comply with ASTM C94 or ASTM C685.

- ACI 318
- ACI 332
- ASTM C94/C94M – 09a – 11c

61

Discussion Item

What is the maximum number of drum revolutions permitted & maximum batch time allowed before ready- mixed concrete must be deposited?

62

American Concrete Institute 332R-84

Redi-mix concrete.

Trip ticket to identify concrete mix proportions (Minimum Compressive Strength per IRC table R402.2 … 2,500 psi typical).

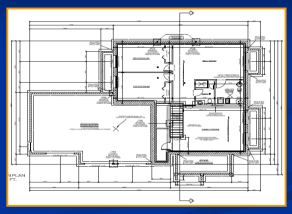
Air entrainment (if required … 5 to 7 percent).

~~Travel time~~ and drum rotation (1 $^{1}/_{2}$ hours and 300 revolutions maximum).

63

Plans and Other Paperwork

- Approved plans must be on site
- Address, lot and block correct on plans



64

Plans and Other Paperwork

- **Survey**

Should be verify that the proposed dwelling will work on the lot.

Local planning and zoning

65

Elevation

- **Survey**
  - **Location on lot**
  - **Setbacks (zoning code).**
  - **Elevations of structure (footings, top of foundation, garage floor).**
  - **Grade drainage.**

66

Location Identified

Survey.

Easier to check the setbacks on the plan than to move the house!

Handout

67

Footing Elevation

- Form Survey
  - Location on the Lot
  - Check the Form survey
  - Finished Floor Elevation

68

Plans and Other Paperwork

Is it to Late???

It's to Late now!!!!

69

Elevation

70

Plans and Other Paperwork

- Plan matches forms

71

Lot Benching

- Lot benching appropriately for design
- Benching should allow for proper drainage
  - R401.3 Drainage.
  - Surface drainage must be diverted to a storm sewer conveyance or other approved point of collection that does not create a hazard. Lots must be graded to drain surface water away from foundation walls. The grade must fall a minimum of 6" within the first 10' feet.
    - Exception: Where lot lines , walls, slopes or other physical barriers prohibit 6" of fall within 10', drains or swales shall be constructed to ensure drainage away from the structure. Impervious surfaces within 10' of the building foundation shall be sloped a minimum of 2 percent away from the building.

72

R401.3 Drainage

- **Surface drainage shall be diverted to an approved point of collection with a minimum fall of 6 inches within the first 10 feet.**
  - **Exceptions:**
  - **Drains or swales must be constructed to ensure drainage away from the structure**
  - **Impervious surfaces within 10' of the foundation must slope minimum of 2% away from building.**


73

Piers

- Check location on lot or form survey. Be sure to also look up!
- Enough forms up to locate foundation and piers
- Does the plan specify number, size, shape, depth, location and reinforcement?
- Water in piers. Due to soil and site can the water be removed?

74

Piers


75

Footings

- Minimum 2500psi concrete (Table R402.2)
- Reinforcement 3" from bottom (R403.1.3.5.3)
- Minimum depth extend below frost line but be at least 12" into undisturbed soil (R403.1.4)
- Top of footing level. Bottom slope not to exceed 10% or be stepped. (R403.1.5)

R403

76

Foundations Types

- Slab on grade
  - Post-tension
  - Conventional (rebar)
- Suspended foundation


- Pier and beam

77

Form Placement

- Forms should be braced, tight and set to prevent displacement
- Slab exposure above grade
  - R404.1.6 Height above finished grade.
  - Concrete and masonry foundation walls must extend above the finished grade adjacent to the foundation at all points a minimum of 4" where masonry veneer is used and a minimum of 6" elsewhere.

78

R404.1.3.3.5 Consolidation of concrete.

- Concrete shall be consolidated by suitable means during placement and shall be worked around embedded items and reinforcement and into corners of forms.
- Where stay-in-place forms are used, concrete shall be consolidated by internal vibration.

R404.1.3.3.6 Form materials and form ties.

- Forms shall be made of wood, steel, aluminum, plastic, a composite of cement and foam insulation, a composite of cement and wood chips, or other approved material suitable for supporting and containing concrete.
- Forms shall provide sufficient strength to contain concrete during the concrete placement operation.

79

Water / Cement Ratio

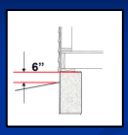
Permeability

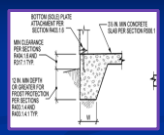
- After concrete cures, those capillary voids let water and vapor move through finished **slabs** and walls.

Consolidated

80

Height above grade





Concrete and masonry foundation walls shall extend above the finished grade adjacent to the foundation at all points a minimum of 4 inches where masonry veneer is used and a minimum of 6 inches elsewhere.

R404.1.6

81

Grade Beam

- Beam location, depth and width should be per plan
- Beams shall be a minimum of 12" into undisturbed soil
- Beams shall be free of debris and water
- Beams can deviate around plumbing but the design engineer should be notified of this condition and approve the deviation.

82

Beam

83

Other Trade Requirements

- Verify concrete encased electrode is installed
- All penetrations are sleeved and copper or PVC is protected
- Mechanical underground is properly installed
- Review onsite inspection card

84

Penetrations

A 6-mil polyethylene or approved vapor retarder with joints lapped not less than 6" shall be placed between the concrete floor slab and the base course or the prepared subgrade where a base course does not exist. **Excepts: 1-4**

R506.2.3

85

HVAC Inspected

86

87

Footing Inspection

Redi-mix.

Slump (is a measure of the consistency of the concrete and should be the minimum that will permit efficient placing of the concrete).

Minimum specified compressive strength of concrete ($f'c$) 2500, 3000 or 3500 depending on weather and the location

88

Table R402.2

TABLE R402.2
MINIMUM SPECIFIED COMPRESSIVE STRENGTH OF CONCRETE

TYPE OR LOCATION OF CONCRETE CONSTRUCTION	MINIMUM SPECIFIED COMPRESSIVE STRENGTH[1] (f'_c)		
	Weathering Potential[2]		
	Negligible	Moderate	Severe
Basement walls, foundations and other concrete not exposed to the weather	2,500	2,500	2,500[3]
Basement slabs and interior slabs on grade, except garage floor slabs	2,500	2,500	2,500[3]
Basement walls, foundation walls, exterior walls and other vertical concrete work exposed to the weather	2,500	3,000[4]	3,000[4]
Porches, carport slabs and steps exposed to the weather, and garage floor slabs	2,500	3,000[4,5]	3,500[4,5]

- What is the compressive strength of this concrete?
- How much water has been added?
- How long has it been between batch plant & placement or rotations?

89

To Verify Compliance

- Batch Ticket
- 1
- 2
  - **Section 14 of ASTM**

Designation: C94/C94M – 09a

Standard Specification for Ready-Mixed Concrete

90

Concrete and Masonry Foundation Walls

Concrete and masonry foundation walls shall be selected and constructed in:

- Accordance with the provisions of Section R404 *or*
- Accordance with ACI 318, ACI 332, PCA 100, TMS 402

- When ACI 318, ACI 332, PCA 100 or TMS 402 *or* the provisions of Section R404 & 608 are used:
  - to design concrete or masonry foundation walls,
  - project drawings,
  - typical details *and* specifications *are not* required to bear the seal of the architect or engineer responsible for design,
  - *unless* otherwise required by the state law of the jurisdiction having authority.

R404.1.2 & R404.1.3

91

92

Requirements

- Foundation construction shall be capable of accommodating all loads according to Section R301 and of transmitting the resulting loads to the supporting soil. Fill soils that support footings and foundations shall be designed, installed and tested in accordance with accepted engineering practice.
- Gravel fill used as footings for wood and precast concrete foundations shall comply with Section R403. [R401.2]

93

R401.4.2 Compressible or shifting soil

- Section 401.4.2 allows the removal of compressible or shifting soils to a depth and width sufficient to assure stable moisture content.
- Fill soils supporting footings and foundations to be designed, installed and tested in accordance with accepted engineering practice

When will the plans examiner know that the soil needs to be addressed?

94

Drought

95

Footing

- Soil.
  - Type of soil (is it undisturbed original material or compacted fill?).
  - Is the soil bearing capacity appropriate for the design of the footings?
  - Free of frost, ice, or standing water.

96

Footing

Buried Debris.

97

TABLE R405.1
PROPERTIES OF SOILS CLASSIFIED ACCORDING TO THE UNIFIED SOIL CLASSIFICATION SYSTEM

SOIL GROUP	UNIFIED SOIL CLASSIFICATION SYSTEM SYMBOL	SOIL DESCRIPTION	DRAINAGE CHARACTERISTICS[a]	FROST HEAVE POTENTIAL	VOLUME CHANGE POTENTIAL EXPANSION[a]
Group I	GW	Well-graded gravels, gravel sand mixtures, little or no fines	Good	Low	Low
	GP	Poorly graded gravels or gravel sand mixtures, little or no fines	Good	Low	Low
	SW	Well-graded sands, gravelly sands, little or no fines	Good	Low	Low
	SP	Poorly graded sands or gravelly sands, little or no fines	Good	Low	Low
	GM	Silty gravels, gravel-sand-silt mixtures	Good	Medium	Low
	SM	Silty sand, sand-silt mixtures	Good	Medium	Low
Group II	GC	Clayey gravels, gravel-sand-clay mixtures	Medium	Medium	Low
	SC	Clayey sands, sand-clay mixture	Medium	Medium	Low
	ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity	Medium	High	Low
	CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays	Medium	Medium	Medium to Low
Group III	CH	Inorganic clays of high plasticity, fat clays	Poor	Medium	High
	MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts	Poor	High	High
Group IV	OL	Organic silts and organic silty clays of low plasticity	Poor	Medium	Medium
	OH	Organic clays of medium to high plasticity, organic silts	Unsatisfactory	Medium	High
	Pt	Peat and other highly organic soils	Unsatisfactory	Medium	High

98

Reality

At each of the boring locations, we recommend the following excavation depths:

Boring Number	Surface Elevation (ft)	Estimated Excavation Depth, 1500 psf (ft)	Estimated Excavation Elevation, 1500 psf (ft)*
1	1181.5	2	1179 ½
2	1193	2	1191
3	1180	12	1168
4	1189.5	2	1187 ½
5	1178	4 ½	1173 ½
6	1183	2	1181

*Estimated to the nearest half-foot; additional excavation may be required to reach footing grade or for frost protection.

Soils Report by the engineer

99

Foundations

Table R401.4.1
Presumptive Load-Bearing Values of Foundation Materials[a]

Class of Material	Load-Bearing Pressure (Pounds per Square Foot)
Crystalline bedrock	12,000
Sedimentary and foliated rock	4,000
Sandy gravel and/or gravel (GW and GP)	3,000
Sand, silty sand, clayey sand, silty gravel and clayey gravel (SW, SP, SM, SC, GM, and GC)	2,000
Clay, sandy clay, silty clay, clayey silt, silt and sandy silt (CL, ML, MH, and CH)	1,500[b,c]

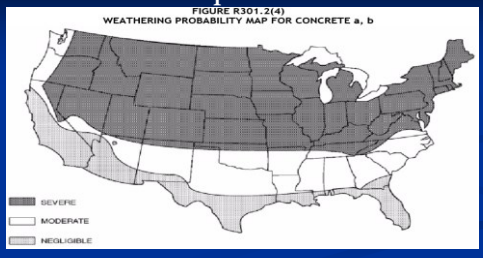
a. When soil tests are required by Section R401.4, the allowable bearing capacities of the soil shall be part of the recommendations.

b. Where the building official determines that in-place soils with an allowable bearing capacity of less than 1,500 psf are likely to be present at the site, the allowable bearing capacity shall be determined by a soils investigation.

100

IRC Map for Concrete

FIGURE R301.2(4)
WEATHERING PROBABILITY MAP FOR CONCRETE a, b



101

Foundation Materials

Table R402.2
Minimum Specified Compressive Strength of Concrete

Type or location of Concrete Construction	Minimum Specified Compressive Strength [a] (f'_c)		
	Weathering potential [b]		
	Negligible	Moderate	Severe
Basement walls, foundations and other concrete not exposed to the weather	2,500	2,500	2,500[c]
Basement slabs and interior slabs on grade, except garage floor slabs	2,500	2,500	2,500[c]
Basement walls, foundation walls, exterior walls, and other vertical concrete work exposed to the weather	2,500	3,000[d]	3,000[d]
Porches, carport slabs and steps exposed to the weather, and garage floor slabs	2,500	3,000[d, e, f]	3,500[d, e, f]

Figure R301.2(3)

102

Footings R403

- All exterior walls shall be supported on continuous solid or fully grouted masonry or concrete footings
- Footings shall be supported on undisturbed natural soils or engineered fill.

R403.1, R602.10.9 item 2

Results of improper backfilling under slab.
8" void below slab.

Footings – Table R403

TABLE R403.1(1)
MINIMUM WIDTH AND THICKNESS FOR CONCRETE FOOTINGS FOR LIGHT-FRAME CONSTRUCTION (inches)[a, b, c, d]

GROUND SNOW LOAD OR ROOF LIVE LOAD	STORY AND TYPE OF STRUCTURE WITH LIGHT FRAME	LOAD-BEARING VALUE OF SOIL (psf)					
		1,500	2,000	2,500	3,000	3,500	4,000

TABLE R403.1(2)
MINIMUM WIDTH AND THICKNESS FOR CONCRETE FOOTINGS FOR LIGHT-FRAME CONSTRUCTION WITH BRICK VENEER OR LATH AND PLASTER (inches)[a, b, c, d]

GROUND SNOW LOAD OR ROOF LIVE LOAD	STORY AND TYPE OF STRUCTURE WITH BRICK VENEER	LOAD-BEARING VALUE OF SOIL (psf)					
		1,500	2,000	2,500	3,000	3,500	4,000

TABLE R403.1(3)
MINIMUM WIDTH AND THICKNESS FOR CONCRETE FOOTINGS WITH CAST-IN-PLACE CONCRETE OR PARTIALLY GROUTED MASONRY WALL CONSTRUCTION (inches)[a, b, c, d]

GROUND SNOW LOAD OR ROOF LIVE LOAD	STORY AND TYPE OF STRUCTURE WITH CMU OR CONCRETE	LOAD-BEARING VALUE OF SOIL (psf)					
		1,500	2,000	2,500	3,000	3,500	4,000

a. Linear interpolation of footing width is permitted between the soil bearing pressures in the table. Extrapolation is not permitted.
b. The table is based on the following conditions and loads: building width, 32 feet; wall height, 9 feet; basement wall height, 8 feet; dead loads, 15 psf roof and ceiling assembly, 10 psf floor assembly, 10 psf wall assembly; live loads, roof and ground snow loads as listed, 40 psf first floor, 30 psf second and third floors. Footing sizes were calculated assuming a clear span roof/ceiling assembly and an interior bearing wall or beam at each floor.
c. Where the building width perpendicular to the wall footing is greater than 32 feet, the footing width shall be increased by 2 inches and footing depth shall be increased by 1 inch for every 4 feet of increase in building width.
d. Where the building width perpendicular to the wall footing is less than 32 feet, a 2-inch decrease in footing width and 1-inch decrease in footing depth is permitted for every 4 feet of decrease in building width provided that the minimum width is 12 inches and minimum depth is 6 inches.

Footings – Table R403

TABLE R403.1(1)
MINIMUM WIDTH AND THICKNESS FOR CONCRETE FOOTINGS FOR LIGHT-FRAME CONSTRUCTION (inches)[a, b, c, d]

GROUND SNOW LOAD OR ROOF LIVE LOAD	STORY AND TYPE OF STRUCTURE WITH LIGHT FRAME	LOAD-BEARING VALUE OF SOIL (psf)					
		1,500	2,000	2,500	3,000	3,500	4,000
50 psf	1 story—slab-on-grade	12 × 6	12 × 6	12 × 6	12 × 6	12 × 6	12 × 6
	1 story—with crawl space	14 × 6	12 × 6	12 × 6	12 × 6	12 × 6	12 × 6
	1 story—plus basement	16 × 6	13 × 6	12 × 6	12 × 6	12 × 6	12 × 6
	2 story—slab-on-grade	15 × 6	13 × 6	12 × 6	12 × 6	12 × 6	12 × 6
	2 story—with crawl space	17 × 6	13 × 6	12 × 6	12 × 6	12 × 6	12 × 6
	2 story—plus basement	21 × 7	15 × 6	12 × 6	12 × 6	12 × 6	12 × 6
	3 story—slab-on-grade	18 × 6	13 × 6	12 × 6	12 × 6	12 × 6	12 × 6
	3 story—with crawl space	20 × 6	15 × 6	12 × 6	12 × 6	12 × 6	12 × 6
	3 story—plus basement	24 × 8	18 × 6	14 × 6	12 × 6	12 × 6	12 × 6

MINIMUM DESIGN DEAD LOADS FOR TYPICAL RESIDENTIAL COMPONENTS

COMPONENT	LOAD (psf)
CEILINGS	
Acoustical fiber tile	1
Gypsum board (per $\frac{1}{2}$-inch thickness)	0.55
Mechanical duct allowance	4
Plaster on tile or concrete	5
Plaster on wood lath	8
Suspended steel channel system	2
Suspended metal lath and cement plaster	15
Suspended metal lath and gypsum plaster	10
Wood furring suspension system	2.5
COVERINGS, ROOF AND WALL	
Asbestos-cement shingles	4
Asphalt shingles	2
Cement tile	16
Clay tile (for mortar add 10 lb)	
Book tile, 2-inch	12
Ludowici, 2-inch	10
Ludowici	10
Roman	12
Spanish	18
Composition:	
Three-ply ready roofing	1
Five-ply felt and gravel	5.5
Five-ply felt and gravel	6
Copper or tin	1
Corrugated asbestos-cement roofing	4
Deck, metal, 20 gage	2.5
Deck, metal, 18 gage	3
Decking, 2-inch wood (Douglas fir)	6
Decking, 3-inch wood (Douglas fir)	8
Fiberboard, $\frac{1}{2}$-inch	0.75
Gypsum sheathing, 2-inch	6
Insulation, roof boards (per inch thickness)	
Cellular glass	0.7
Fiberboard	1.5
Perlite	1.5
Polystyrene foam	0.2
Urethane foam with skin	0.5
Plywood (per $\frac{1}{4}$-inch thickness)	0.6
Rigid insulation, 2-inch	0.75
Skylight, metal frame, $\frac{1}{4}$-inch wired glass	8
Slate, $\frac{1}{4}$-inch	10
Slate, $\frac{1}{2}$-inch	10
Waterproofing membrane	
Bituminous, gravel-covered	5.5
Bituminous, smooth surface	1.5
Liquid applied	1.5
Single-ply sheet	0.7
Wood sheathing (per 1-inch thickness)	3
Wood shingles	3

COMPONENT	LOAD (psf)
FLOORS AND FLOOR FINISHES	
Asphalt block (2-inch), 2-inch mortar	30
Cement finish (1-inch) on stone-concrete fill	32
Ceramic or quarry tile ($\frac{3}{4}$-inch) on 2-inch mortar bed	16
Ceramic or quarry tile ($\frac{3}{4}$-inch) on 1-inch mortar bed	13
Concrete, plain (per inch thickness)	12
Hardwood flooring, $\frac{3}{4}$-inch	4
Linoleum or asphalt tile, $\frac{1}{4}$-inch	1
Marble and mortar on stone-concrete fill	33
Slate (per inch thickness)	15
Solid flat tile on 1-inch mortar base	23
Terrazzo (1-inch)	13
Terrazzo (1-inch) directly on slab	12
Terrazzo (1-inch) on stone-concrete fill	32
Terrazzo (1-inch) 2-inch stone concrete	32
Wood block (3-inch) on mastic, no fill	10
Wood block (3-inch) on 2-inch mortar base	16
FLOOR, WOOD-JOIST (NO PLASTER) DOUBLE WOOD FLOOR	

Joint Sizes (inches)	12-in. spacing (lb/ft)	16-in. spacing (lb/ft)	24-in. spacing (lb/ft)
2 × 6	6	5	4
2 × 8	7	6	5
2 × 10	9	8	6
2 × 12	11	9	7

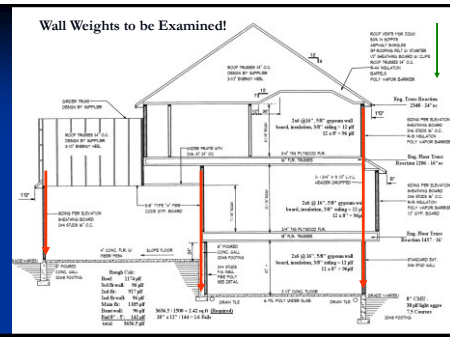
FRAME PARTITIONS	
Movable steel partions	4
Wood or steel studs, 2-inch gypsum board each side	8
Wood studs, 2 × 4, unplastered	5
Wood studs, 2 × 4, plastered one side	12
Wood studs, 2 × 4, plastered two sides	20

FRAME WALLS	
Exterior stud walls:	
2 × 4 @ 16 inches, $\frac{1}{2}$-inch gypsum insulated, $\frac{1}{2}$-inch siding	11
2 × 6 @ 16 inches, $\frac{1}{2}$-inch gypsum insulated, $\frac{1}{2}$-inch siding	12
Exterior stud walls, with brick veneer	40
Windows, glass, frame and sash	8

MASONRY PARTITIONS AND WALLS	
Concrete block, heavy aggregate:	
4-inch	18
6-inch	24
8-inch	33
Concrete block, heavy aggregate:	
4-inch	30
6-inch	45
8-inch	60
12-inch	85
Concrete block, light aggregate:	
4-inch	20
6-inch	28
8-inch	38
12-inch	55

For SI: 1 pound per square foot = 0.0479 kPa, 1 inch = 25.4 mm, 1 pound = 0.4536 kg.
NOTE: Weights of masonry include mortar but not plaster. For plaster add 5 lb/ft² for each inch of plaster. Values given represent averages. In

Wall Weights to be Examined!

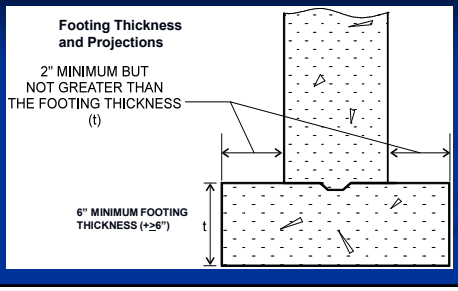


Footing Sizes
Section R403.1.1

- Minimum footing sizes, both for concrete and masonry footings, per Table R403.1 and Figure R403.1(1)
- Footing width (W) based on soil load-bearing value
- Spread footing to be a minimum of 6 inches in thickness
- Footing projections (P) to be a minimum of 2 inches, and in no case less than the thickness of the footing

109

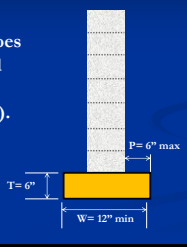
Footing Review - R403.1.1



110

Footing Projection

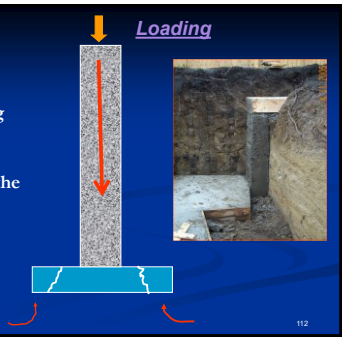
– Footing projection does NOT exceed the footing thickness (T).



– Footing width is a minimum of 12 inches.

111

The over sized footing reacts to the loading and the condition of the soil.



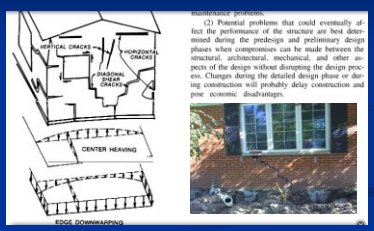
112

Footing Environment Inspection

Verification of:

- Soil type

Example of building on unstable or fill soils



113

What's Required

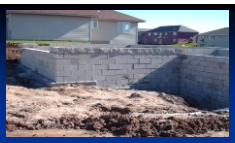
114

Footing Environment

115

WWTP

Where is the footing?



116

Minimum Footing Size

- The size of footings supporting piers and columns shall be based on the tributary load and allowable soil pressure in accordance with Table R401.4.1.

R403.1.1

117

Positive Attachment Of Pier To Foundation Section R502.9

118

R404.1.9 – Isolated Masonry Piers

…Hollow masonry piers shall have a min. nominal thickness of 8",

Height not exceeding ***four*** times the nominal thickness and a nominal length not exceeding ***three*** times the nominal thickness.

Where hollow masonry units are ***solidly filled*** with concrete or grout, piers **shall be** permitted to have a nominal height *not exceeding ten times* the nominal thickness.

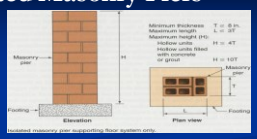
Footings for isolated masonry piers shall be sized according R403.1.1. (1 out of 6 comments)

R404.1.9.2 Masonry piers supporting floor girders

119

R404.1.9 – Isolated Masonry Piers

This section provides prescriptive requirements for the construction of isolated masonry pier foundations supporting raised floor systems.



120

Remove at least…

- **R403.1.4 Minimum depth**
- All exterior footings shall be placed at least 12" below the undisturbed ground surface.
- Where applicable, the depth of footings shall also conform to Sections R403.1.4.1 through R403.1.4.2.

121

R403.1 Footings

- Exterior footings to be placed at least 12 inches below undisturbed ground
- EXCEPT WHERE OTHERWISE PROTECTED FROM FROST, FOUNDATION WALLS, PIERS AND OTHER PERMANENT SUPPORTS TO BE PROTECTED BY:
- extending below frost line, or
- constructing per R403.3 (frost-protected shallow foundations), or
- constructing per ASCE 32-01 (frost-protected foundations), or
- erected on solid rock
- Top surface of footings to be level
- Bottom surface of footings limited to 1:10 slope
  - Stepped footings may be used where 1:10 slope exceeded

122

Footings

123

Footing Continuity, Surface & Step

- Focus:
  - Continuous
  - Level
  - Slope

The top surface of footings shall be level.

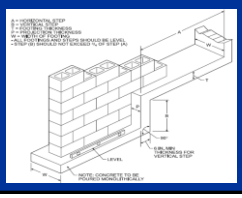
R403.1.5 Slope.

124

Footing Inspection

Slope.

"Footings shall be stepped where it is necessary to change the elevation of the top surface of the footing…"



WWTP - Unless

IRC section R403.1.5

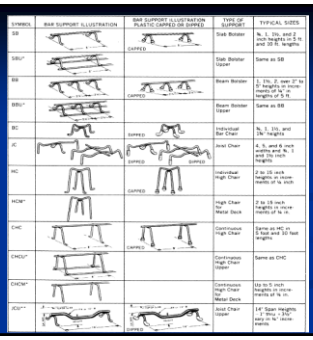
125

126

Bar Support

Reinforcement shall be secured in the proper location in the forms with tie wire or other bar support system to prevent displacement during the concrete placement operation. Steel reinforcement in concrete cast against the earth shall have . . . .

R403.1.3.5.3 Support and cover.



127

Site Preparation

Removal of debris from Under-Floor Space "Crawl Space". The under-floor grade shall be cleaned of all vegetation and organic material… *IRC R408.4*

Backfill Under-Floor Space. The remainder of the excavated area shall be backed filled with the same type of soil as was removed during the excavation. *IRC R406.3.4*

Concrete Floor - Site preparation. The area within the foundation walls shall have all vegetation, top soil and foreign material removed. *R506.2*

Concrete Floors Fill. Fill material shall be free of vegetation and foreign material. The fill shall be compacted to assure uniform support of the slab, and except where approved, the fill depths shall not exceed 24 inches for clean sand or gravel and 8 inches for earth. R506.2.1

128

Reality

129

Reality

130

131

Provide bulkheads when concrete pour is not continuous.

132

133

134

Footing Inspection

Protection due to weather.

Cold weather.

Hot weather.

Rain.

135

136

Cold Weather Rule

- Cold weather concreting is a common and necessary practice, and every cold weather application must be considered carefully to accommodate its unique requirements. The current American Concrete Institute definition of cold-weather concreting, as stated in ACI 306 is, "a period when for more than 3 successive days the average daily air temperature drops below 5°C (40°F) and stays below 10°C (50°F) for more than one-half of any 24 hour period." This definition can potentially lead to problems with freezing of the concrete at an early age.

  Rule number one is that ALL concrete must be protected from freezing until it has reached a minimum strength of 3.5 MPa (500 psi), which typically happens within the first 24 hours. In addition, whenever air temperature at the time of concrete placement is below 5°C (40°F) and freezing temperatures within the first 24 hours after placement are expected, the following general issues should be considered: (1) Initial concrete temperature as delivered; (2) Protection while the concrete is placed, consolidated, and finished, and (3) Curing temperatures to produce quality concrete.

Portland Concrete Association

137

Cold weather construction

American Concrete Institute (ACI) 318 references "Cold Weather Concreting" in ACI 306.

The following items are discussed in the ACI 306 report:

Recommended temperature of concrete, temperature of materials, placement preparations, duration of protection period, methods of determining in-place strength, form removal, protective insulating covers, heated enclosures, curing methods, and accelerating admixtures.

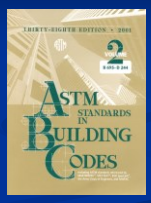
IRC, section R404.1

138

Cold weather construction

Mortar for use in masonry construction shall comply with ASTM C270 (American Society for Testing and Materials).

It includes subjects such as storage of materials, mixing of materials, mortar specifications, test methods, admixtures, tempering, bond, workability, durability, strength, etc.

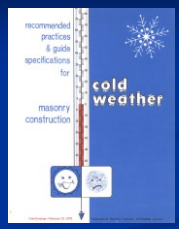


IRC, section R607.1

139

Cold weather construction

In section 7.5 of ASTM C270, "Climatic Conditions," it states "…cold weather masonry construction relating to mortar shall comply with the International Masonry All-Weather Council's "Guide Specification for Cold Weather Masonry Construction."



ASTM C270

140

Cold weather construction

This "guide" will include specific provisions for heating of material, and when to provide enclosures…such as:

20 degrees and below. Heat mixing water and sand to produce mortar temperatures between 40 degrees and 120 degrees. Provide enclosures and supply sufficient heat to maintain masonry enclosure above 32 degrees for 24 hours.

American Society for Testing and Materials C270

141

Cold weather construction

American Concrete Institute (ACI) 530 TMS 402, the "Specification for Masonry Structures," this document will include specific provisions related to cold weather, such as:

Heat mortar sand or mixing water to produce mortar temperatures between 40 degrees and 120 degrees at the time of mixing. When ambient temperature is below 20 degrees, provide an enclosure for the masonry under construction and use heat sources to maintain temperatures above 32 degrees within the enclosure…and for 24 hours after completion of the masonry.

IRC, section R404.1.2

142

Cold weather construction

The "National Concrete Masonry Association" has published a "Hot & Cold Weather Masonry Construction Manual" which is available.

(TR 088) Hot & Cold Weather Masonry Construction Manual

Used as a reference guide for above & below normal temperature conditions, this manual is based on the provisions of Specification for Masonry .Structures (ACI 530.1-99/ASCE 6-99/TMS)602-99. 20 pages (1999) Retail: $ 10

Price: $ 7.00

add to your products

(The NCMA's contact information is on the following page)

143

Cold weather construction

The "National Concrete Masonry Association" has also published a document called their TEK manual. In section TEK 3-1C, "All-Weather Concrete Masonry Construction," it also contains provisions for cold weather, hot weather, rain, snow, wet weather and windy weather. See next slide. The TEK manual can be purchased, or it can be down-loaded (free) from any of their members' websites.

National Concrete Masonry Association
13750 Sunrise Valley Drive
Herndon, Va 20171-3499
703/713-1900
Website www.ncma.org

144

Cold weather construction

In TEK 3-1C, "All-Weather Concrete Masonry Construction," it will include specific provisions for heating of material, and when to provide enclosures…

Heat sand or water to produce mortar temperatures between 40 degrees and 120 degrees. When the ambient temperature is 20 degrees and below, provide an enclosure for the masonry under construction and use heat sources to maintain temperature above 32 degrees within the enclosure.

145

Cold Weather Requirements

Requirements Cumulative From Top to Bottom of Chart

General Preparation and Construction Requirements: Store units and other materials in dry conditions off the ground. Do not lay frozen units (those with temperatures below 20° F) or those with visible ice or snow. Do not heat water or aggregates above 140° F. It's not necessary to heat grout materials unless their temperatures are below 32° F.

TEMPERATURE RANGES	CONSTRUCTION REQUIREMENTS Ambient Temperatures (During Construction)	PROTECTION REQUIREMENTS Mean daily temps for un-grouted masonry, and anticipated daily minimums for grouted masonry for period following construction
40° F to 32° F	▪ Do not lay glass units. ▪ Heat sand or water to achieve mortar temps of 40° F to 120° F, at time of mixing.	▪ Maintain glass unit masonry above 40° F for 48-hours. ▪ Protect newly laid masonry with weather-resistant membrane for 24-hours.
32° F to 25° F	▪ Maintain materials above 32° F until used. ▪ Heat grout aggregate & water. ▪ Keep grout above 70° F.	▪ No additional requirements beyond those above.
25° F to 20° F	▪ Add windbreaks or enclosures when wind exceeds 15 mph. ▪ Heat masonry to 40° F prior to grouting.	▪ Cover new masonry completely with insulating blankets, or equal, for 24-hours. ▪ Increase to 48-hours for grouted masonry unless Type III cement only is used.
20° F and Below	▪ Add auxiliary heat to enclosures. ▪ Keep area above 32° F.	▪ Maintain new masonry temps above 32° F for 24-hours with heated enclosures, lamps, etc.

ACI 530/TMS 402 Masonry

146

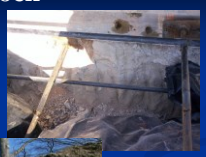
Soils

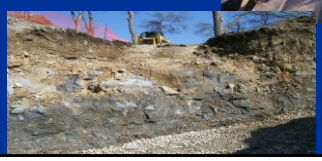
Compactions

147

Solid Rock

- Solid rock or rocky soil
- Grade beams must be full depth unless solid rock is encountered.





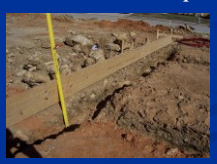
148

Solid Rock

149

Solid Rock

- Beam must be a minimum of 12" deep and 2" into solid rock
- Do not penetrate rock more than 2" as this will socket beams into rock and this will hinder slab compression



Acceptable engineer practice

150

151

Footing Inspection

Inspection record.

Approval required.

(the inspector) … "shall either indicate the portion of the construction that is satisfactory as completed or notify the permit holder … of any failures to comply with the code."

Paper trail – Documentation

152

Understanding & Inspecting Foundations

153

THE *CONCRETE REINFORCING STEEL INSTITUTE* provides the following guidelines for soil properties:

"Class A", at 30 psf, includes clean sand, gravel, and broken stone, free of fines that might obstruct free drainage.

"Class B", at 45 psf, includes granular soils, mixed grain sizes, dense enough to cause low permeability.

"Class C", at 62.5 psf, fine, silty sands; granular soils with some clay; some glacial tills.

154

Tables R404.1(1)-(4) versus R404.1(5)

- Both require grade 60 bars
- Concrete allows grade 40 at 2/3 spacing
- Masonry allows both bigger & smaller bar substitutions (up to 72" o.c.)
- Concrete allows smaller bars at closer spacing, but not larger bars at wider spacing
- While masonry used standardized bar sizes & spaces, concrete used exact numbers (such as #7 @ 31" o.c.)
- Both make no mention of dowels except (Stay-in-place forms)
- Masonry makes no mention of horizontals
- Concrete requires horizontals only if verticals are needed (two at 8 foot tall and three at 9 foot)

155

Deformed Bar Identification

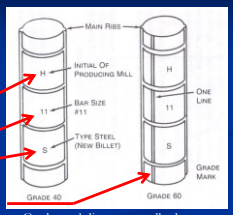
Steel reinforcement.

Is steel required?

What grade of steel?

Grade marks:
(1st) Producing mill.
(2nd) Bar size number.
(3rd) Type S for Billet.

Grade 60 must also show "60" or One Line for 60,000 psi strength.



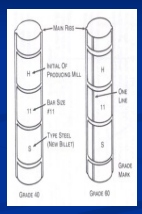
Grade mark lines are smaller between the two main longitudinal rib

156

Deformed steel bars

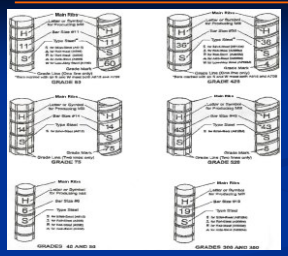
Minimum Yield Designation

- For grade 60 bars, either the number 60 or a single continuous longitudinal line through at least five spaces offset from the center of the bar side.
- For grade 75 bars, either the number 75 or two continuous longitudinal lines through at least five spaces offset each direction from the center of the bar.
- No marking designation for Grade 40.



157

Deformed Bar



ASTM A 615/A 615M – 01 "Deformed and Plain Billet-Steel Bars for Concrete Reinforcement and Concrete Reinforcing Steel Institute

158

Deformed Steel Bars

In the United States, bars sizes have been described using the term "inch-pound" units. In 1997, the steel mills in the United States began to phase in the production of "soft metric" bars.

The term "soft metric" means describing the nominal dimensions of inch-pound reinforcing bars in metric units. The physical size of the bars did not change, just the method to describe them.

ASTM A 615/A 615M – 01 "Deformed and Plain Billet-Steel Bars for Concrete Reinforcement and Concrete Reinforcing Steel Institute

160

Deformed steel bars

Soft Metric Bar Sizes vs. Inch-Pound Bar Sizes

Soft Metric Bar Size Designation	Inch-Pound Bar Size Designation
#10	#3
#13	#4
#16	#5
#19	#6
#22	#7
#25	#8
#29	#9
#32	#10
#36	#11
#43	#14
#57	#18

161

Deformed Steel Bars

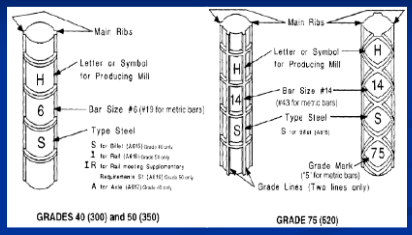
Minimum yield strengths or grades.

Inch-pound (psi)	Soft metric (megapascals)
40 (40,000)	300 MPa
50 (50,000)	350 MPa
60 (60,000)	420 MPa
75 (75,000)	520 MPa

ASTM A 615/A 615M – 01 "Deformed and Plain Billet-Steel Bars for Concrete Reinforcement and Concrete Reinforcing Steel Institute

162

Deformed Bar Identification



163

OLD TABLE

Table 5-G — Length of lap (inches)[1]

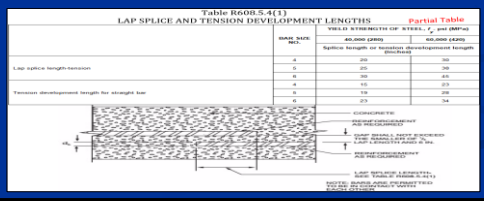
Bar Size		Grade 40		Grade 60				UBC Concrete	
No.	Dia.	UBC Masonry 30 Dia.	UBC Masonry 40 Dia.	36 Dia.	48 Dia.	50 Dia.	60 Dia.	Dev. Lgth	Top Bars
3	.375	12	15	14	18	19	23	12	12
4	.500	15	20	18	24	25	30	12	12
5	.625	19	25	23	30	31	38	12	16
6	.750	23	30	27	36	38	45	16	22
7	.875	27	35	32	42	44	51	22	30
8	1.000	30	40	36	48	50	60	28	39
9	1.128	34	45	41	54	56	68	36	50
10[2]	1.270	39	50	45	61	64	76	44	62
11[2]	1.410	43	56	50	68	71	85	56	78

[1] Working Stress Design
[2] Not permitted for UBC Strength Design

164

R404.1.3.3.7.5 Lap splices

… Where splices are necessary in reinforcement, the length of lap splice shall be in accordance with Table R608.5.4.(1) and Figure R608.5.4(1).



165

Lap Splice

166

. . . accordance to acceptable engineer practices

Where lap splicing of vertical or horizontal reinforcing steel is necessary, the lap splice shall be in …

167

Rebar Reinforced Foundations

- Steel should conform to ASTM-615 Grade 60
- Clean reinforcement of loose rust and mill scale, earth, ice, and other materials which reduce or destroy bond with concrete.
- Splices should be placed at point of minimum stress

168

Rebar Reinforced Foundations

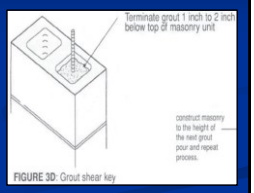
169

Bending Deformed Reinforcement

170

Rebar Reinforced Foundation

- **Placement reinforcement to obtain at least minimum coverage for concrete protection. Bars are to be arranged, space and securely tied and bar supports to hold reinforcement in position during concrete placement operations.**
- **Bend reinforcing bars cold. No Torch**
- **Bars are to be placed according to approved plan and details.**



171

General of Coverage of Bar

- Reinforcement shall be secured in the proper location in the forms with tie wire or other bar support system to prevent displacement during the concrete placement operation.
- Steel reinforcement in concrete cast against the earth shall have a minimum cover of 3".
- Minimum cover for reinforcement in concrete cast in removable forms that will be exposed to the earth or weather shall be $1^1/_2$" for No. 5 bars and smaller, and 2" for No. 6 bars and larger.
- For concrete cast in removable forms that will not be exposed to the earth or weather, and for concrete cast in stay-in-place forms, minimum cover shall be $^3/_4$".

R403.1.3.5.3 Support and cover.

172

173

12" Masonry Foundation Walls with Reinforcing

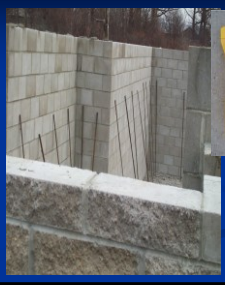
Table R404.1.1(4)

c. . . . The distance from the face of the soil side of the wall to the center of vertical reinforcement shall be at least 8.75 inches..

At no time shall any reinforcement be placed against cmu walls – TMS 402 section 1.12

174

Placement of Vertical Reinforcement



175

ACI – Bundling

ACI 530 ….1.12.3.4 Groups of parallel reinforcing bars bundled in contact to act as a unit shall limited to two in any one bundle. …. or ACI 318 …7.7.4

176

Change in thickness

Where walls of masonry of hollow units or masonry bonded hollow walls are decreased in thickness, a course of solid masonry shall be constructed between the wall below and the thinner wall above, or special units or construction shall be used to transmit the loads from face shells or wythes above to those below.

R606.4.3 Change in thickness.

177

IRC 606 & TMS 402

ACI 530 - 5.6.2 Walls

5.6.2.1 Minimum thickness – The minimum thickness of masonry bearing walls more than one story high shall be 8 in. Bearing walls of one story buildings shall not be less than 6 in. thick.

5.6.2.3 Changes in thickness – Where walls of masonry of hollow units or masonry bonded hollow walls are decreased in thickness, a course or course of solid masonry shall be interposed between the wall below and the thinner wall above, or special units or construction shells or wythes above to those below.

178

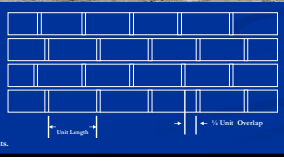
Minimum thickness

- **The minimum thickness of masonry bearing walls more than one story high shall be 8 inches. Solid masonry walls of one story dwellings and garages shall not be less than 6 inches in thickness.**
- Backfill shall not be placed against the wall until the wall has sufficient strength and has been anchored to the floor above, or has been **sufficiently braced to prevent** damage by the backfill.

R606.4.1 & R404.1.7 Backfill placement

179

ACI 530 - 1.11 & R606



Vertical Reinforcement Location?

Placement?

Running Bond

Stack Bond

R606.3.1 Bed and head joints.

180

Foundation Inspection

Unit masonry.

Mortar joint thickness shall be within the following tolerances from the specified dimensions:

1. Bed joint: + 1/8 inch = (3/8" min. to 7/8" max.)
2. Head joint: -1/4 inch, to + 3/8 inch = (min 1/8 in., max. ¾ in.)
3. Collar joints: -1/4 inch min = "3/8 min., ¾" max

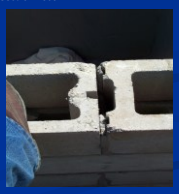
R606.3.1

181

…. voids shall not be permitted

Any units disturbed to the extent that initial bond is broken after initial placement shall be removed and relaid in fresh mortar.

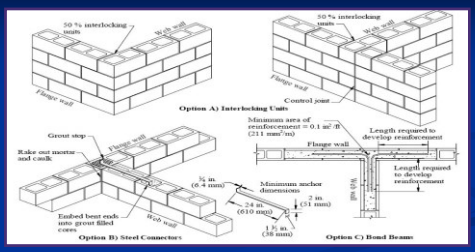
For hollow masonry units, head and bed joints shall be filled solidly with mortar for a distance in from the face of the unit not less than the thickness of the face shell. SectionR606



R606.3.2 Masonry unit placement.

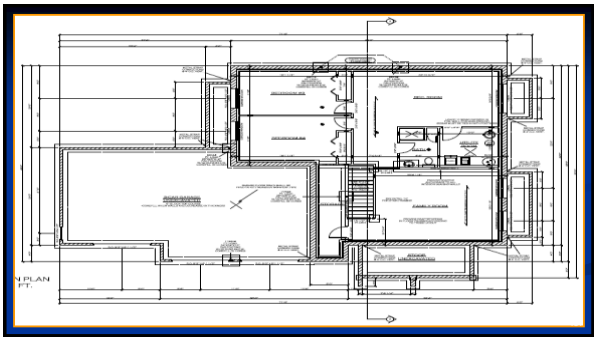
182

Interlocking



Commentary TMS 402 section 1.9.4 Intersecting Walls

183



Intersecting Walls

185

Cast-In-Place

186

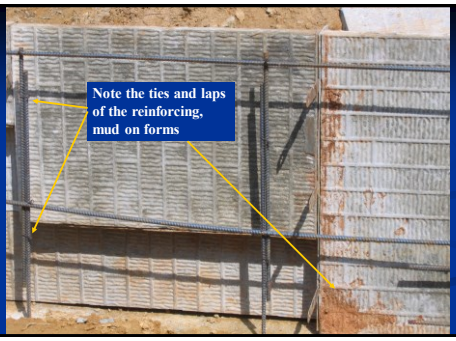
Foundation Walls
Section R404

- Concrete foundation walls shall be selected and constructed in accordance with the provisions of Section R404.1.2.
- [R404.1.2] Concrete foundation walls that support light-frame walls shall be designed and constructed in accordance with the provisions of this section,
  - ACI 318,
  - ACI 332 *or*
  - ACI 530.
  - (PCA 100 has been added to 2009 IRC.

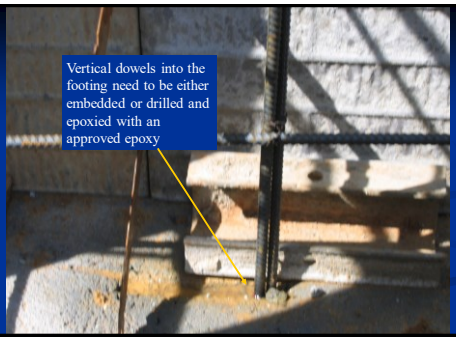
187

188

189



190



191

Foundation Walls

- Unless supporting less than 4 feet of unbalanced fill, backfill not to be placed until wall is anchored to floor above or sufficiently braced R404.1.7 *dd*
- Special provisions for Seismic Design Categories D_1 and D_2

192

Plain Masonry Foundation Walls

- Table R404.1(1).
- Known values:
  - Wall height.
  - Height of unbalanced fill (≥ 4')
  - Lateral earth pressure (soil type)

193

Table R404.1.1(1)
Plain Masonry Foundation Walls [a]

MAXIMUM WALL HEIGHT (feet)	MAXIMUM UNBALANCED BACKFILL HEIGHT[c] (feet)	PLAIN MASONRY[b] MINIMUM NOMINAL WALL THICKNESS (inches)		
		Soil classes[f]		
		GW, GP, SW and SP	GM, GC, SM, SM-SC and ML	SC, MH, ML-CL and inorganic CL
5	4 5	6 solid[d] or 8 6 solid[d] or 8	6 solid[d] or 8 8	6 solid[d] or 8 10
6	4 5 6	6 solid[d] or 8 6 solid[d] or 8 8	6 solid[d] or 8 8 10	6 solid[d] or 8 10 12
7	4 5 6 7	6 solid[d] or 8 6 solid[d] or 8 10 12	8 10 10 10 solid[d]	8 10 10 solid[d] 12 solid[d]
8	4 5 6 7 8	6 solid[d] or 8 6 solid[d] or 8 10 12 10 grout[d]	6 solid[d] or 8 12 12 12 solid[d] 12 grout[d]	8 12 12 solid[d] Footnote e Footnote e
9	4 5 6 7 8 9	6 grout[d] or 8 solid[d] or 12 8 grout[d] or 10 solid[d] 8 grout[d] or 12 solid[d] 10 grout[d] 10 grout[d] 12 grout	6 grout[d] or 8 solid[d] 8 grout[d] or 12 solid[d] 10 10 grout[d] 12 grout Footnote e	8 grout[d] or 10 solid[d] 8 grout[d] 10 10 grout[d] 12 grout Footnote e Footnote e

d. Solid grouted hollow units or solid masonry units.

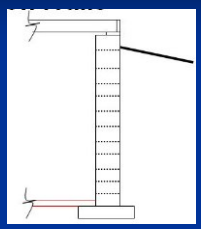
194

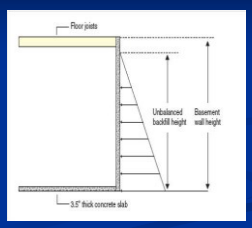
Reinforced Masonry Walls

- R404.1.1(2) for 8" walls.
- R404.1.1(3) for 10" walls.
- R404.1.1(4) for 12" walls.
- Known values:
  - Wall height.
  - Height of unbalanced backfill.
  - Lateral earth pressure.

195

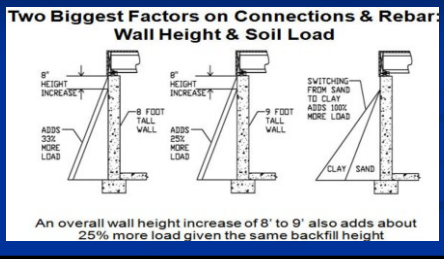
Foundation Wall





196

Foundation Wall



197

TABLE R404.1.1(2)
8-INCH MASONRY FOUNDATION WALLS WITH REINFORCING WHERE d > 5 INCHES[a]

WALL HEIGHT	HEIGHT OF UNBALANCED BACKFILL[c]	MINIMUM VERTICAL REINFORCEMENT[b,d] Soil classes and lateral soil load[e] (psf per foot below grade)		
		GW, GP, SW and SP soils 30	GM, GC, SM, SM-SC and ML soils 45	SC, ML-CL and inorganic CL soils 60
6 feet 8 inches	4 feet (or less)	#4 at 48" o.c.	#4 at 48" o.c.	#4 at 48" o.c.
	5 feet	#4 at 48" o.c.	#4 at 48" o.c.	#4 at 48" o.c.
	6 feet 8 inches	#4 at 48" o.c.	#5 at 48" o.c.	#5 at 48" o.c.
7 feet 4 inches	4 feet (or less)	#4 at 48" o.c.	#4 at 48" o.c.	#4 at 48" o.c.
	5 feet	#4 at 48" o.c.	#4 at 48" o.c.	#5 at 48" o.c.
	6 feet	#4 at 48" o.c.	#5 at 48" o.c.	#5 at 48" o.c.
	7 feet 4 inches	#5 at 48" o.c.	#6 at 48" o.c.	#6 at 48" o.c.
8 feet	4 feet (or less)	#4 at 48" o.c.	#4 at 48" o.c.	#4 at 48" o.c.
	5 feet	#4 at 48" o.c.	#4 at 48" o.c.	#4 at 48" o.c.
	6 feet	#4 at 48" o.c.	#5 at 48" o.c.	#5 at 48" o.c.
	7 feet	#5 at 48" o.c.	#6 at 48" o.c.	#6 at 40" o.c.
	8 feet	#5 at 48" o.c.	#6 at 48" o.c.	#6 at 32" o.c.
8 feet 8 inches	4 feet (or less)	#4 at 48" o.c.	#4 at 48" o.c.	#4 at 48" o.c.
	5 feet	#4 at 48" o.c.	#4 at 48" o.c.	#5 at 48" o.c.
	6 feet	#4 at 48" o.c.	#5 at 48" o.c.	#5 at 48" o.c.
	7 feet	#5 at 48" o.c.	#6 at 48" o.c.	#6 at 40" o.c.
	8 feet 8 inches	#6 at 48" o.c.	#6 at 32" o.c.	#6 at 24" o.c.
9 feet 4 inches	4 feet (or less)	#4 at 48" o.c.	#4 at 48" o.c.	#4 at 48" o.c.
	5 feet	#4 at 48" o.c.	#4 at 48" o.c.	#5 at 48" o.c.
	6 feet	#4 at 48" o.c.	#5 at 48" o.c.	#5 at 48" o.c.
	7 feet	#5 at 48" o.c.	#6 at 48" o.c.	#6 at 40" o.c.
	8 feet	#6 at 48" o.c.	#6 at 40" o.c.	#6 at 24" o.c.
	9 feet 4 inches	#6 at 40" o.c.	#6 at 24" o.c.	#6 at 16" o.c.
10 feet	4 feet (or less)	#4 at 48" o.c.	#4 at 48" o.c.	#4 at 48" o.c.
	5 feet	#4 at 48" o.c.	#4 at 48" o.c.	#5 at 48" o.c.
	6 feet	#4 at 48" o.c.	#5 at 48" o.c.	#6 at 48" o.c.
	7 feet	#5 at 48" o.c.	#6 at 48" o.c.	#6 at 32" o.c.
	8 feet	#6 at 48" o.c.	#6 at 32" o.c.	#6 at 24" o.c.
	9 feet	#6 at 40" o.c.	#6 at 24" o.c.	#6 at 16" o.c.
	10 feet	#6 at 32" o.c.	#6 at 16" o.c.	#6 at 16" o.c.

198

Concrete Foundation Wall

- Flat slab design tables:
  - Horizontal reinforcement per Table R404.1.2(1).
  - Vertical reinforcement:
    - Tables R404.1.2(2)-(4): rebar in center.
    - Table R404.1.2(8): rebar 1 ¼" from inside face.
- Known values:
  - Maximum wall height.
  - Height of unbalanced backfill (>4').
  - Lateral earth pressure.
  - Wall thickness.
  - Location of rebar

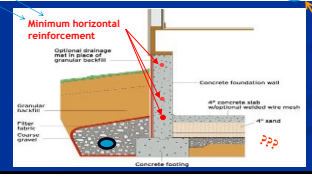
199

Minimum Horizontal Rebar

- Known value: wall height

TABLE R404.1.2(1)
MINIMUM HORIZONTAL REINFORCEMENT FOR CONCRETE BASEMENT WALLS[a, b]

MAXIMUM UNSUPPORTED HEIGHT OF BASEMENT WALL (feet)	LOCATION OF HORIZONTAL REINFORCEMENT
≤ 8	One No. 4 bar within 12 inches of the top of the wall story and one No. 4 bar near mid-height of the wall story
> 8	One No. 4 bar within 12 inches of the top of the wall story and one No. 4 bar near third points in the wall story



200

Flat Wall: Vertical Rebar in Center

TABLE R404.1.2(3)
MINIMUM VERTICAL REINFORCEMENT FOR 8-INCH (203 mm) NOMINAL FLAT CONCRETE BASEMENT WALLS[a, c, d, e, f, h, i]

MAXIMUM UNSUPPORTED WALL HEIGHT (feet)	MAXIMUM UNBALANCED BACKFILL HEIGHT[g] (feet)	MINIMUM VERTICAL REINFORCEMENT—BAR SIZE AND SPACING (inches) Soil classes[a] and design lateral soil (psf per foot of depth) GW, GP, SW, SP 30	GM, GC, SM, SM-SC and ML 45	SC, ML-CL and inorganic CL 60
8	4	NR	NR	NR
	5	NR	NR	NR
	6	NR	NR	6 @ 37
	7	NR	6 @ 36	6 @ 35
	8	6 @ 41	6 @ 35	6 @ 26
9	4	NR	NR	NR
	5	NR	NR	NR
	6	NR	NR	6 @ 35
	7	NR	6 @ 35	6 @ 32
	8	6 @ 36	6 @ 32	6 @ 23
	9	6 @ 35	6 @ 25	6 @ 18

Do not miss the footnotes

201

Flat Wall: Vertical Rebar on Inside Face

TABLE R404.1.2(8)
MINIMUM VERTICAL REINFORCEMENT FOR 6-, 8-, 10-INCH AND 12-INCH NOMINAL FLAT BASEMENT WALLS[a, c, d, e, f, h, i, k, n]

MAXIMUM WALL HEIGHT (feet)	MAXIMUM UNBALANCED BACKFILL HEIGHT[g] (feet)	MINIMUM VERTICAL REINFORCEMENT—BAR SIZE AND SPACING (inches) Soil classes[a] and design lateral soil (psf per foot of depth) GW, GP, SW, SP 30	GM, GC, SM, SM-SC and ML 45	SC, ML-CL and inorganic CL 60	Minimum nominal wall thickness (inches) 6	8	10	12	6	8	10	12	6	8	10	12
8	4	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
	5	NR	NR	NR	NR	NR	NR	NR	4 @ 38	NR[l]	NR	NR	5 @ 43	NR	NR	NR
	6	4 @ 37	NR[l]	NR	NR	5 @ 37	NR	NR	NR	6 @ 37	5 @ 43	NR[l]	NR	NR	NR	NR
	7	5 @ 40	NR	NR	NR	6 @ 37	5 @ 41	NR[l]	NR	6 @ 34	6 @ 43	NR	NR	NR	NR	NR
	8	6 @ 43	5 @ 47	NR[l]	NR	6 @ 34	6 @ 43	NR	NR	6 @ 27	6 @ 32	6 @ 44	NR	NR	NR	NR
9	4	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
	5	NR	NR	NR	NR	4 @ 35	NR[l]	NR	NR	5 @ 40	NR	NR	NR	NR	NR	NR
	6	4 @ 34	NR[l]	NR	NR	6 @ 48	NR	NR	NR	6 @ 36	6 @ 39	NR[l]	NR	NR	NR	NR
	7	5 @ 36	NR	NR	NR	6 @ 34	5 @ 37	NR	NR	6 @ 33	6 @ 38	5 @ 37	NR[l]	NR	NR	NR
	8	6 @ 38	5 @ 41	NR[l]	NR	6 @ 33	6 @ 28	5 @ 37	NR[l]	6 @ 29	6 @ 29	6 @ 39	4 @ 48[m]	NR	NR	NR
	9	6 @ 34	6 @ 46	NR	NR	6 @ 26	6 @ 30	6 @ 41	NR	6 @ 19	6 @ 23	6 @ 30	6 @ 39	NR	NR	NR

Do not miss the footnotes

202

Alternate Bar Size

TABLE R404.1.2(9)
MINIMUM SPACING FOR ALTERNATE BAR SIZE AND/OR ALTERNATE GRADE OF STEEL[a, b, c]

BAR SPACING FROM APPLICABLE TABLE IN SECTION R404.1.2.2 (inches)	BAR SIZE FROM APPLICABLE TABLE IN SECTION R404.1.2.2															
	#4			#5						#6						
	Alternate bar size and/or alternate grade of steel desired															
	Grade 60		Grade 40			Grade 60		Grade 40			Grade 60		Grade 40			
	#5	#6	#4	#5	#6	#4	#6	#4	#5	#6	#4	#5	#4	#5	#6	
	Maximum spacing for alternate bar size and/or alternate grade of steel (inches)															
24	37	48	16	25	35	15	34	10	16	23	11	17		11	16	
25	39	48	17	26	37	16	35	11	17	24	11	18		12	17	
26	40	48	17	27	38	17	37	11	17	25	12	18		12	17	
27	42	48	18	28	40	17	38	12	18	26	12	19		13	18	
28	43	48	19	29	41	18	40	12	19	26	13	20		13	19	
29	45	48	19	30	43	19	41	12	19	27	13	20		14	19	
30	47	48	20	31	44	19	43	13	20	28	14	21		14	20	
31	48	48	21	32	45	20	44	13	21	29	14	22		15	21	
32	48	48	21	33	47	21	45	14	21	30	15	23		15	21	
33	48	48	22	34	48	21	47	14	22	31	15	23		16	22	
34	48	48	23	35	48	22	48	15	23	32	15	24		16	23	
35	48	48	23	36	48	23	48	15	23	33	16	25		16	23	

203

Laterally Supported

R404.1.2.2 Reinforcement for foundation walls.
Concrete foundation walls shall be **laterally supported** at the top and bottom.

R606.9 Lateral support.
Masonry walls shall be **laterally supported** in either the horizontal or the vertical direction.

204

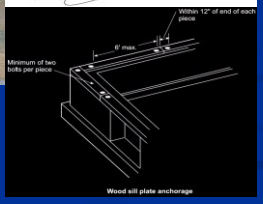
R403.1.6 Foundation Anchorage

1. Minimum Of Two Anchor Bolts Per Plate Section.
2. One Bolt Located Not More Than 12 Inches Nor Less Than Seven Bolt Diameters From Each End Of Each Plate.
3. Bolts Shall Be At Least ½" Diameter And EMBEDDED A Minimum Of Seven Inches Into Masonry Or Concrete.
4. The bolts shall be located in the middle third of the width of the plate.

Alternate Anchor System

211

3" MIN.
ANCHOR BOLT & NUT
HEAVY DUTY WASHER
SILL PLATE
7" MIN.

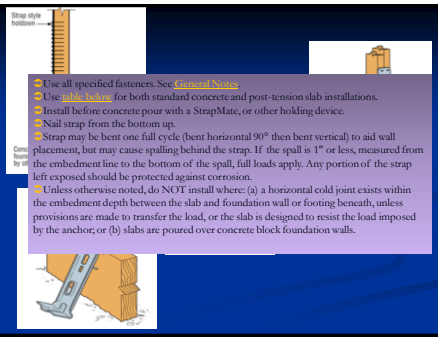


What size washer?

212

213

214



- Use all specified fasteners. See General Notes.
- Use nails below for both standard concrete and post-tension slab installations.
- Install before concrete pour with a StrapMate, or other holding device.
- Nail strap from the bottom up.
- Strap may be bent one full cycle (bent horizontal 90° then bent vertical) to aid wall placement, but may cause spalling behind the strap. If the spall is 1" or less, measured from the embedment line to the bottom of the spall, full loads apply. Any portion of the strap left exposed should be protected against corrosion.
- Unless otherwise noted, do NOT install where: (a) a horizontal cold joint exists within the embedment depth between the slab and foundation wall or footing beneath, unless provisions are made to transfer the load, or the slab is designed to resist the load imposed by the anchor; or (b) slabs are poured over concrete block foundation walls.

215

Foundation

Foundation anchorage.

Question: How close to the edge of the plate can the hole be drilled?

Answer: Yes, middle third, and the National Design Specification for Wood Construction (NDS), for loads perpendicular to the grain, states the minimum edge distance is four times the diameter of the bolt (measured to the center of the bolt).

R403.1.6 & NDS WFCM

216

Foundation

Foundation anchorage.

Question: Are there limitations on the size of the hole for the bolt?

Answer: Although not specifically noted in the code, the NDS specifies that holes drilled for bolts shall be a minimum of 1/32 inch to a maximum of 1/16 inch larger than the bolt diameter (9/16 inch to 5/8 inch for a ½ inch diameter bolt).

2021 IRC R403.1.6 & NDS WFCM

217

Foundation

Foundation anchorage.

Question: Can the sill plate overhang the foundation wall?

Answer: Although not clearly specified in R403.1.6 of the code, in Section 2.4.1.3 of the WFCM, "Bottom Plate," it notes that bottom plates that are connected directly to the foundation shall have full bearing on the foundation.

2021 IRC R602.3.4 and WFCM

218

Foundation

Foundation anchorage.

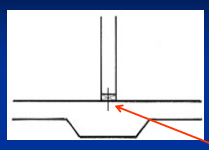
Question: Can the sill plate overhang the foundation wall?

Answer: Although not clearly specified in R403.1.6 of the code, in Section 2.4.1.3 of the WFCM, "Bottom Plate," it notes that bottom plates that are connected directly to the foundation shall have full bearing on the foundation.

2021 IRC R602.3.4 and WFCM

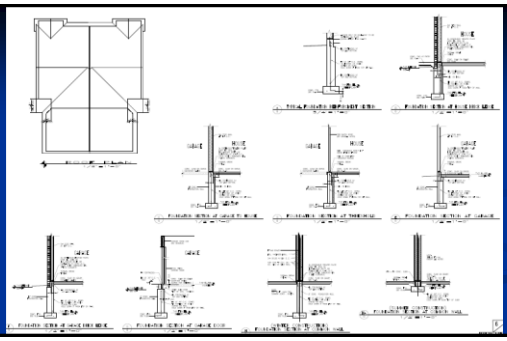
219

Foundation Anchorage



Interior load-bearing walls. *R602.4* Interior load-bearing walls shall be constructed, framed and fireblocked as specified for exterior walls. *R403.1* General. All exterior walls shall be supported on continuous solid or fully grouted masonry or concrete footings, . . . The wood sole plate at exterior walls on monolithic slabs and wood sill plate shall be anchored to the foundation with anchor bolts spaced a maximum of 6 feet on center. R403.1.6 Foundation anchorage. . . . Interior bearing wall sole plates on monolithic slab foundation shall be positively anchored with approved fasteners.

220



221

Foundation anchorage:

Foundation anchor straps spaced as required to provide equivalent anchorage to ½" anchor bolts. When vertical reinforcing is required by other sections of this code, the foundation anchor straps shall align with the reinforcing.

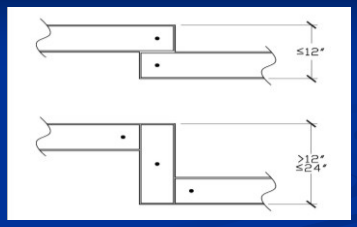
Exceptions:

1. Walls 24" total length or shorter connecting offset braced wall panels shall be anchored to the foundation with a min. of one anchor bolt *located* in the center third of the plate section *and* shall be attached to adjacent braced wall panels according to Figure R602.10.5 at corners.
2. Walls 12" total length or shorter connecting offset braced wall panels shall be permitted to be connected to the foundation without anchor bolts. The wall shall be attached to adjacent braced wall panels according to Figure R602.10.5 at corners.

R403.1.6

222

Anchor Layout Exception at Short Walls



R403.1.6

223

Other Important Items

- Stoops
- Slopes
- Unbalanced exterior grade
- Footing steps
- Brick ledges

Quote by structural engineer

224

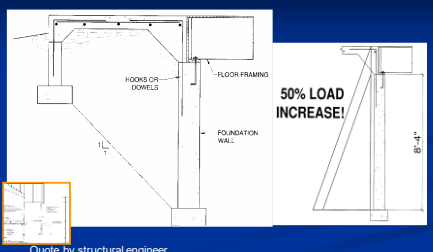
Issues With Stoops

- Grade higher than the wall
  - Extreme load increase
  - Flashing/wood protection
- Voids under slab
  - Compaction
  - Structural Slab
- May require dowel support

Quote by structural engineer

225

Stoop Example Detail



Quote by structural engineer

226

Masonry Industry Standards ACI 530/TMS 402

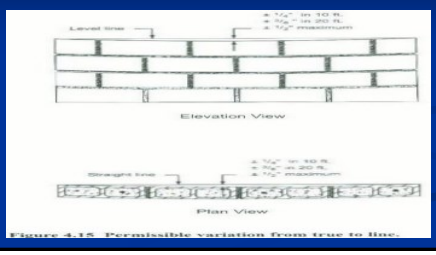


Figure 4.15 Permissible variation from true to line.

227

Footings on or Adjacent to Slopes Section R403.7

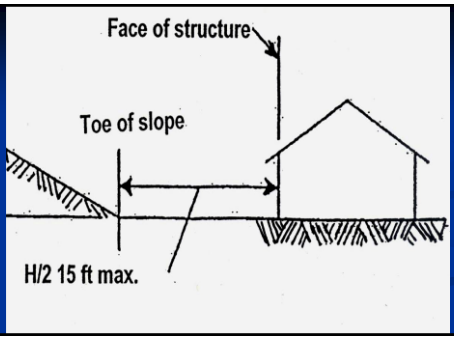
- Provisions applicable for slopes steeper than 1:3
- Buildings <u>below slopes</u> to be protected from slope drainage, erosion and shallow failures
  - Figure R403.1.7.1 indicates complying setback from toe of slope to face of structure
  - Additional criteria for slopes exceeding 1:1
- Buildings at <u>top of slope</u> to be protected from movement due to detrimental settlement
  - Figure R403.1.7.1 indicates complying setback from top of slope to face of footing
  - Additional criteria for slopes exceeding 1:1

228

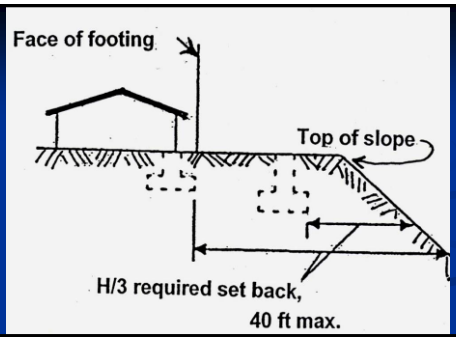
No elevation plan has been submitted & none required.

How does the plans examiner know how to review this dwelling?

229



230



231

Footings on or Adjacent to Slopes

Section RR403.1.7.3

- On graded sites, top of exterior foundation to extend above street gutter at discharge point a minimum of 12 inches plus 2%

ZONING

- Alternate setbacks, clearances and drainage elevations permitted when approved by the building official

232

Poured

Reinforcing steel & anchor devices must be secured in place prior to placing concrete.

WWTP

R506.2.4 Reinforcement support

233

ICF/ Stay-in-place forms

234

Stay-in-place forms

- Stay-in-place concrete forms shall comply with this section.

1. Surface burning characteristics. The flame-spread index and smoke-developed index of forming material, other than foam plastic, left exposed on the interior shall comply with Section R302. The surface burning characteristics of foam plastic used in insulating concrete forms shall comply with Section R316.3.

2. Interior covering. Stay-in-place forms constructed of rigid foam plastic shall be protected on the interior of the building as required by Section R316. Where gypsum board is used to protect the foam plastic, it shall be installed with a mechanical fastening system. Use of adhesives in addition to mechanical fasteners is permitted.

R404.1.3.3.6.1

235

Stay-in-place forms

3. Exterior wall covering. Stay-in-place forms constructed of rigid foam plastics shall be protected from sunlight and physical damage by the application of an approved exterior wall covering complying with this code. Exterior surfaces of other stay-in-place forming systems shall be protected in accordance with this code.

4. Termite protection. In areas where the probability of termite infestation is "very heavy" as indicated by Table R301.2(1) or Figure R301.2(7), foam plastic insulation shall be permitted below grade on foundation walls in accordance with Section R318.4.

5. Flat ICF wall system forms shall conform to ASTM E2634.

236

One Engineer's Report

Minimum Lap Splice Lengths*

Bar Size	Lap Length	Max Non-Contact Lap Separation
#4 (1/2" ⌀)	23"	5"
#5 (5/8" ⌀)	25"	5"
#6 (3/4" ⌀)	26"	6"
#7 (7/8" ⌀)	33"	6"

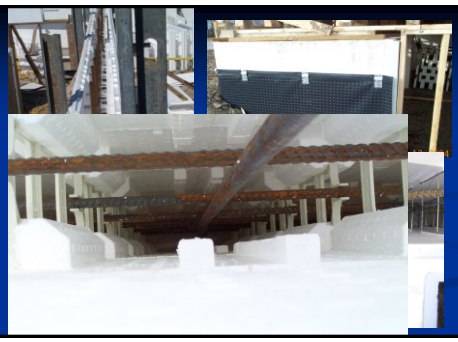
* Chart based upon ACI 318-05 Section 12.15
Class B
f'c = 3,000 psi
fy = 60,000 psi
Normal weight concrete
Offset bar location in wall

237

Coverage and Clearances

238

239



240

Dampproofing and Flashing


241


242

- This photograph is taken inside the large void in the "Insulated Concrete Form". The light blue sides are the insulation, the black cross members hold the insulation together and the vertical steel are reinforcing added to the ICF during wall erection. In the far end of the photograph, the concrete has started to flow into the form but for some reason did not fill the void.

243

- **This photograph illustrates a close-up of the concrete beginning to flow into the ICF void. For some reason, the concrete cured before all the ICF form was filled.**

244

- **A second void is discovered in the same wall. This void measures 2' long and 2' high.**

245

R402.3.1 – PRECAST CONCRETE FOUNDATION MATERIALS

This section adds minimum requirements for materials used in the manufacture and installation of precast concrete foundations.


246

RETAINING WALLS

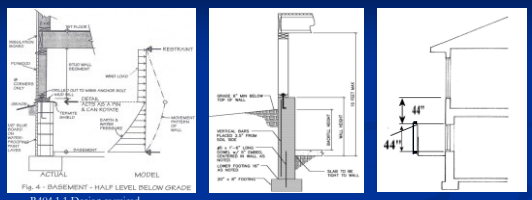


Fig. 4 - BASEMENT - HALF LEVEL BELOW GRADE

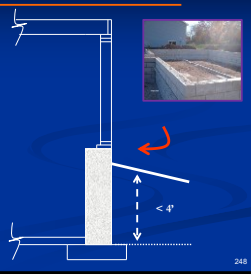
R404.1.1 Design required.
Concrete or masonry foundation walls shall be designed in accordance with accepted engineering practice where either of the following conditions exists:
…2. Walls supporting more than 48" of unbalanced backfill that do not have permanent lateral support at the top or bottom.

247

Laterally Supported Foundation Walls

Concrete or masonry foundation walls shall be designed in accordance with accepted engineering practice when either of the following conditions exists:

1. Walls are subject to hydrostatic pressure from groundwater.
2. Walls supporting more than 48 inches of unbalanced backfill that do not have permanent lateral support at the top or bottom.



R404.1.1 Design required

248

R404.5 Retaining walls

- Retaining walls not laterally supported at the top, retaining more than 24 inches of unbalanced fill shall be designed to ensure stability against overturning, sliding, excessive foundation pressure and water uplift. Safety factor of 1.5 against lateral sliding and overturning required.

249

R404.5 Retaining walls

- Retaining walls not laterally supported at the top, retaining more than 24 inches of unbalanced fill shall be designed to ensure stability against overturning, sliding, excessive foundation pressure and water uplift. Safety factor of 1.5 against lateral sliding and overturning required.

250

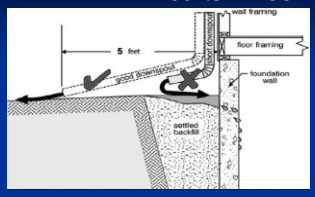
251

Retaining Walls R404.5

- Retaining walls that are not laterally supported at the top …shall be designed to ensure stability against overturning, sliding, excessive foundation pressure and water uplift.

252

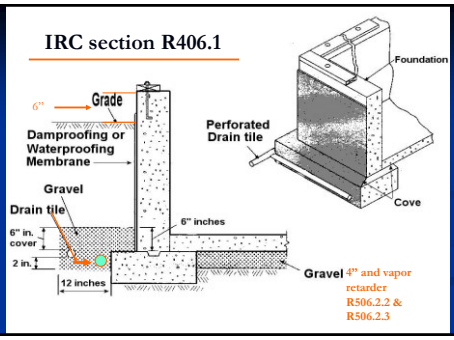
R801.3 - Roof Drainage



R801.3 Roof drainage.
In areas where expansive soils or collapsible soils are known to exist, all dwellings shall have a controlled method of water disposal from roofs that will collect and discharge roof drainage to the ground surface not less than 5 feet from foundation walls or to an approved drainage system.

253

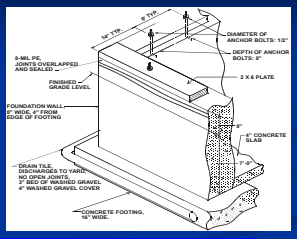
IRC section R406.1



4" and vapor retarder R506.2.2 & R506.2.3

254

Foundation Inspection



Note:
Seismic category: A
Soil classification: SM

Table R405.1

If the approved plan shows a detail like this one how will the inspector do their field inspection by plan or by code?

255

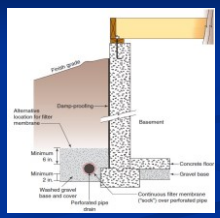
Foundation Drainage Section R405.1

- Unless soils are classified as Group I, drains are required around all concrete or masonry foundations that enclose usable space below grade
- Drain construction may include:
  - drainage tiles,
  - gravel or crushed stone,
  - perforated pipe, or
  - other approved systems or materials
- Drains to discharge by gravity or by mechanical means to an approved drainage system
- Specific installation requirements are provided for gravel or crushed stone drains, as well as for drain tiles

256

R405.1 – CONCRETE OR MASONRY FOUNDATIONS

A filter membrane is now required for perforated foundation drains. **OR**

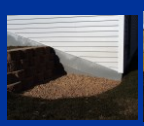


Filter membrane required for perforated pipe foundation drain

257

Dampproofing/waterproofing

The Building Official needs to compare the "standards" or "acceptance criteria" or the "independent testing" of a product to the intended use of that product, and make the decision on whether to approve or not to approve a product.



258

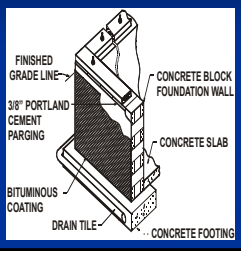
Foundation Waterproofing and Dampproofing

- Dampproofing of foundation walls is required where retaining earth and enclosing habitable or usable spaces below grade
- Masonry walls to be parged with at least 3/8 inch portland cement
  - Parging to be dampproofed by bituminous coating, acrylic modified cement, surface-bonding mortar, or one of listed methods for waterproofing
- Concrete walls to be dampproofed by any listed dampproofing or waterproofing materials

R406

259

Foundation Damproofing & Waterproofing



260

R406.2 Concrete and masonry foundation waterproofing

- Walls shall be water proofed in accordance with one of the following:

1. 2 ply hot mopped felts
2. 55 pound roll roofing
3. 6-mil polyvinyl chloride
4. 6-mil polyethylene
5. 40-mil polymer-modified asphalt
6. 60-mil flexible polymer cement
7. 1/8 inch cement-based, fiber-reinforced, waterproof coating
8. 60-mil solvent-free liquid-applied synthetic rubber. Exception applies to ICF walls

261

Foundation Waterproofing - R406.2

- Requires dampproofing or waterproofing for all concrete and masonry foundations that retain earth and enclose interior spaces and floors below grade.

262

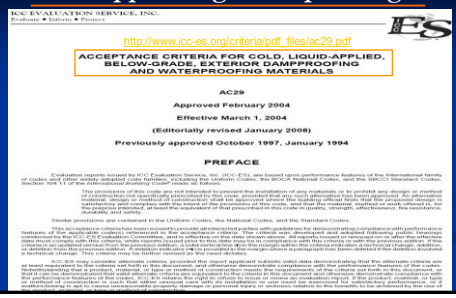
Dampproofing/waterproofing

When a manufactured product, such as foundation dampproofing and foundation waterproofing is proposed to be used instead of the conventional bituminous coating on the foundation wall, the building official will need to verify compliance with the specific code requirements, and any national "standard" pertaining to the product.

The process of getting a product approved is the responsibility of the designer/builder, not the Building Official. The Building Official may look for testing or Evaluation Service reports to determine compliance.

263

Dampproofing/waterproofing



ICC EVALUATION SERVICE, INC.

http://www.icc-es.org/criteria/pdf_files/ac29.pdf

ACCEPTANCE CRITERIA FOR COLD, LIQUID-APPLIED, BELOW-GRADE, EXTERIOR DAMPPROOFING AND WATERPROOFING MATERIALS

AC29

Approved February 2004

Effective March 1, 2004

(Editorially revised January 2008)

Previously approved October 1997, January 1994

PREFACE

264

TABLE 1—TESTING

PROPERTIES	NUMBER OF SPECIMENS	TEST METHOD	REQUIREMENTS
Hydrostatic pressure over cracks[2]	3	ASTM C 1305[3] or ASTM D 5385[3]	50 percent of lowest value achieved
Low-temperature flexibility and crack bridging[2]	5	ASTM C 836, Section 6.7[4]	No cracking, splitting, pinholes or loss of adhesion
Adhesion strength	3	ASTM C 836, Section 6.9	1 lbf/in. on surfaces desired
Resistance to water	3	ASTM D 2939, Section 15	No blistering or reemulsification
Resistance to decay[1]	4	ASTM E 154, Section 13	10 percent maximum weight loss; 1 perm maximum water vapor transmission
Remain in place during application	1	ASTM C 836, Section 6.8	As recommended by manufacturer[5] ±5 mils
Water vapor permeance	3	ASTM E 96, Water Method	Maximum 1 perm
Extensibility after heat aging[2]	3	ASTM C 836, Section 6.11	$\frac{1}{16}$ inch, no cracking

For **SI:** 1 inch = 25.4 mm, 1 mil = 0.0254 mm, 1 lbf/in. = 0.175 N/mm, 1 perm = 5.745 x 10^{-11} kg/pa·s·m^2.

[1]Required for dampproofing only. Sections 13.5.1.2 and 13.5.1.3 of ASTM E 154 may be revised, allowing the test specimen to be placed directly on the concrete before placement into the soil.
[2]Required for waterproofing only.
[3]Manufacturer to recommend the actual wet and dry film thicknesses for testing. The reported thicknesses will be part of the evaluation report.
[4]The test temperature is recommended by the manufacturer. The test temperature must be reported in the test report and be part of the evaluation report.
[5]The test specimen shall be tested over a minimum $\frac{1}{16}$-inch crack.

http://www.icc-es.org/criteria/pdf_files/ac29.pdf

265

Published by Distributors

FOUNDATION WATER-PROOFING

System 17-PMA

System 17 PMA is a cost effective, water or solvent based, polymer-modified asphalt waterproofing material with excellent elastomeric properties. When applied at 40 mil thickness will enable the contractor to offer a 10 year limited warranty. It is engineered to meet or exceed the performance properties of the best polymer modified asphalt coatings. System 17 PMA is designed and recommended for use below grade on exterior foundation walls. This coating was developed for spray application. It provides a tough, durable finish which can bridge shrinkage cracks. System 17 PMA maintains its outstanding properties when exposed to chemicals commonly found in soils.

Property	Test Method	Results
Color	–	Black
Solids	ASTM D 2939	Average 63.05 %
Density	ASTM D 2939	8.44lb/gal
Viscosity Kreb's Stormer	ASTM D 562	220 grams
pH	–	10.35 pH
Adhesion to concrete	ASTM C 836 Spec min 1 lbf/in	10.15 lbf/in Exceeds Specification
Elongation	ASTM D 412	Average 1936%
Recovery from 300% Elongation	ASTM D 412	Average 80%
Low Tempeature Flexibility	1" Mandrel 1"x6" sample	passes 10°F
Liquid Water Absorbtion	ASTM D 1228	0.01%

Pass Fail

266

267

Base Course

- R506.2.2 Base.
- A 4"-thick base course consisting of clean graded sand, gravel, crushed stone or crushed blast-furnace slag passing a 2-inch sieve shall be placed on the prepared subgrade when the slab is below grade .
  - Exception: A base course is not required when the concrete slab is installed on well-drained or sand-gravel mixture soils classified as Group I according to the United Soil Classification System in accordance with Table R405.1.

268

269

Vapor retarder

A minimum 10-mil (0.010 inch; 0.254 mm) vapor retarder conforming to ASTM E1745 Class A requirements with joints lapped not less than 6" shall be placed between the concrete floor slab and the base course or the prepared subgrade where a base course does not exist.

Exception: The vapor retarder is not required for the following:

1. Garages, utility buildings and other unheated *accessory structures*.
2. For unheated storage rooms having an area of less than 70 sq. ft and carports.
3. Driveways, walks, patios and other flatwork not likely to be enclosed and heated at a later date.
4. Where *approved* by the *building official*, based on local site conditions.

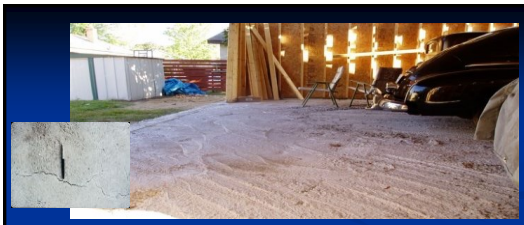
R506.2.3

270

271

R506.2.4 Reinforcement support.
Where provided in slabs on ground, reinforcement shall be supported to remain in place from the center to upper one third of the slab for the duration of the concrete placement.

272



R309.1 Floor surface. - Garage floor surfaces shall be of approved noncombustible material.

The area of floor used for parking of automobiles or other vehicles shall be sloped to facilitate the movement of liquids to a drain or toward the main vehicle entry doorway.

273

274

275

Short Cut

Learn from the mistakes of others.
You can never live long enough
To make them all yourself.

276

Summary

- Verify all code requirements.
- Call your local building department with questions.
- …And remember: "Life is good." (Brent Snyder 2006)

277